ENGINEERING

An Illustrated Weekly Journal

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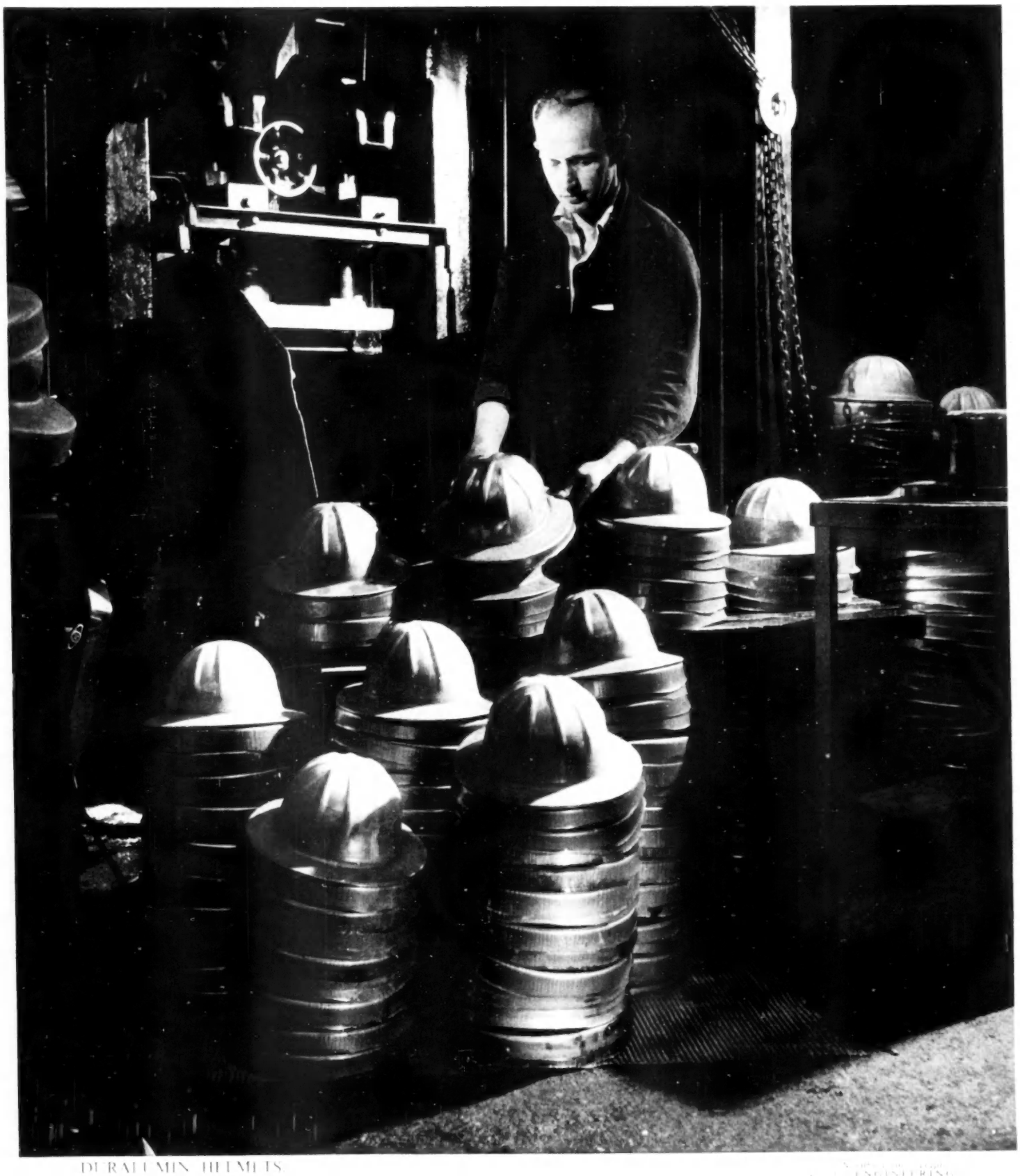

DURALUMIN HELMETS

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ENGINEERING

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DO NOT DESPAIR

ARE we living in a declining society? Adolf Hitler was not the first to confront us with this question; nor will he be the last. Yet Adolf Hitler and his 1,000-year Reich are gone, and we are still here. Now that the prospect of disarmament gives us a breathing space and the hope that civilisation—not only our own—may survive a little longer, it is high time that we Europeans looked to our decline and decided whether or not we are going to succumb.

Probably the most formidable exponent of Western senility has been Dr. Arnold Toynbee, whose ten-volume *A Study of History* treats civilisations as living entities, comparing them with each other, and likening them to men, in that they grow, flourish and decay. This interpretation of history is not new; the Italian, Giovanni Battista Vico, detected a cyclic pattern in history, and the German, Oswald Spengler, in *Der Untergang des Abendlandes* (Decline of the West) presented a depressing corpus of learning in support of it. Dr. Toynbee curiously dates our decline from well before the Renaissance, putting a somewhat moral complexion on the matter, as if we were suffering from the consequences of the Fall rather than simply old age. In particular, this dating means that we embarked on the downward path even before the birth of Leonardo da Vinci, let alone the Industrial Revolution; so it would appear that Dr. Toynbee regards the growth of science and technology as at best irrelevant to the idea of civilisation (both to its quality or rating and to its vigour) and at worst a symptom of degeneracy.

To examine such a view—and we are conscious that to doubt the results of so much scholarship and study involves at least an element of presumption—it is necessary to establish some generally acceptable, if rudimentary, criteria for civilisation. All the civilisations treated in *A Study of History* appear to have both comprehensive organisation and prosperity, enabling at least a part of the population to indulge in pursuits unconnected with the immediate needs of survival. In addition, as civilisations proceed in time they achieve an increasing refinement of communication, not merely in its extent and intricacy, but in the subtlety of the ideas conveyed. Thus to appreciate the work of Mr. James Thurber, a fair degree of sophistication is necessary, based perhaps on *Reveille* and rising through *Punch*, Mr. Danny Kaye and the Marx Brothers, to the obliquer humour of the *New Yorker*. Similarly, the power of Pheidias to communicate the Athenian idea of godhead in stone and bronze required a refinement that could only have arisen on the tiered talents of his predecessors.

None of these criteria presupposes decay, and it is only if we are attracted to the anthropomorphic view of society, as children are inclined to ascribe human attributes to their pets and playthings, are we likely to accept the inevitability of our decline. Dr. Toynbee proceeds beyond simple analogy (which is never a sound basis for extrapolation) to point out that "when people are translated—whether in 'real life' or in imagination—from conditions of pressure into conditions of ease, the effect upon their behaviour is demoralising." The transition from a tough peasant existence to a cultivated urban life may certainly be softening in some respects, and it is true too that, with increased specialisation and complexity of organisation, society becomes more inflexible and fragile, more likely to succumb under environmental changes; but none of these tendencies lead to an inevitable conclusion.

With our own civilisation and the advent of technology, the situation has entirely changed. The means and paths of communication have multiplied so vastly that not only are more people engaged in the process of assimilation, but civilisations can no longer develop in isolation. Thus Europe has already acquired to some extent the experimental outlook of America, and will in time adopt what is useful in the plodding empiricism of Russia. As China, India and Africa proceed to their fulfilment we shall likewise assume whatever benefits they may evolve. There will thus be a continuous process of revitalisation, as the Hyksos Shepherd Kings brought new blood to the decaying strength of Egypt at the end of XIVth Dynasty. Unlike its predecessors, our civilisation is a dynamic one, placing its faith in change.

Technology has also made possible more flexible and effective social organisation. Diocletian ensured the continued survival of the Roman Empire for several centuries by introducing systematic administration, though in fact he lacked the tools. With modern communications and data processing, survival might be extended indefinitely.

But the greatest change in our situation wrought by science and engineering lies in our new relationship with our environment. No longer do we need a peasant toughness to survive times of hardship; a sudden change in climate is not now a serious hazard. Even if in a few centuries an alteration in the solar system makes our earth uninhabitable, it is reasonable to suppose that some of our descendants will be able to establish colonies elsewhere.

Humanity is more resilient than it has ever been, and Europe too. Though J. M. Keynes rightly foresaw European disaster

in the stripping of Germany after the first world war, both Europe and Germany have survived—but illustrating at the same time Europe's interdependence. Professor H. R. Trevor-Roper writing in *Encounter* declares that Europe has not declined; it is merely relatively overshadowed by the larger areas which it has brought to life. An article on page 186 of this issue emphasises the need for unity in Europe to combat this overshadowing. As never before, men can assume responsibility for their own future; no longer need we trust to the metaphysics of fate. The danger lies in acceptance of a prescribed doom. As Professor Trevor-Roper suggests, a contributory reason for France's defeat in 1940 was a belief that the West was already in decline and that Hitler was invincible. Our decline is no more certain than was his invincibility.

* * *

Plain Words

A survey made by the American magazine *Fortune* uncovered that half the companies in the United States made " wife-screening " a regular practice before taking on staff. Among *Fortune's* findings was that one-fifth of all otherwise capable applicants are turned down because of their wives. In Britain, privacy has long been one of our most cherished privileges, and any attempt to bring about such an invasion of the home in this country is likely to be strongly resisted—and rightly so. Man is best able to withstand the strains of modern life by adopting a bipolar pattern of living—one environment serving as refreshment for the other. The office can as often provide solace for the tired domestic man as the home or its equivalent for the long-lamented business man. But without a proper separation of powers there can be no sense of respite, no restorative effect.

Wife-screening as a systematic routine is certainly undesirable, but a friendly casual contact at a social level, with conclusions drawn intuitively, is considerably more acceptable, and probably more useful. The danger lies in carrying such a process to the extremes apparently practised in America. A distinction should be drawn too between screening for the wife's potential effect on the work of the man, and screening for her value as a social asset to the firm. Both perhaps have their place, but the manner in which they are carried out is everything.

The British Institute of Management take the view that the office is one world and the home another, but recognise that wives can sometimes feel left out. They plan to include in their November conference subjects likely to be of interest to wives and to women generally. Among the topics proposed are " Home Management" and " The Extent to which a Wife should Interest Herself in Her Husband's Business Affairs."

It is wholly desirable that husband and wife should share their work and worries as much as possible. But the spread of understanding is one thing, the invasion of the home another.

TELFORD: MAN OF HIS AGE

Thomas Telford, the bi-centenary of whose birth occurs today, August 9, was a rounded personality as well as a great engineer. He would have been utterly puzzled by the debates in this age about giving engineers a smattering of the humanities in their early training to avoid the evils of over-specialisation. To a man such as he there could be no such issue to discuss. He had the Eighteenth Century attitude in such matters and for him engineering was a particular form of expression of the cultured man. He once wrote that it had been his endeavour to bring together " literature and business." These were his words while first President of the Institution of Civil Engineers to a schoolmaster friend; he thereby set the stamp of a liberal attitude to his own career and an ideal for his profession.

Telford did not know it, but the circumstances of his times gave him a unique opportunity to fulfil his destiny. He ranks with Metcalfe and Macadam (many would say ahead of them) as an exponent of improved communications as the Industrial Revolution gathered impetus. He was there with the others to give those better roads and bridges which the new steam age required for the next stage of its development. He therefore belonged to a wider and equally distinguished gathering which included such men as Tull, Arkwright, Cartwright and Watt.

This son of an Eskdale shepherd developed his abilities along many lines. His desire to unite literature and business remained no more than an ideal. His poetic fragments were conventional in style. But the motive behind his remark played an important part in reconciling the artist, the engineer and the business man in him. Telford was incapable of thinking and working like a glorified clerk of works on the one hand or as an artist with his head in the clouds on the other. He was " the compleat engineer." His debt to classical architecture was to be seen in his Pont Cysylte aqueduct built across the Dee at Llangollen in 1803 and many years later in the Menai suspension bridge. A capacity to handle a new medium came with his Buildwas bridge in 1796 for which he used cast iron, on which he did some of the earliest experiments to determine its yield point and ultimate tensile strength.

From the very beginning Telford displayed great quantities of energy and enthusiasm. He had learnt the fundamentals of his trade at first hand, building walls, repairing cottages, buildings and even small bridges. At the same time he was more than merely a working mason for he treated his occupation as a craft to be mastered. At the age of 26, and after having come to London, the chance came to leave the ranks of operative masons to take a post as a supervisor of other people's work—the erection of a house for the Commissioner of Portsmouth. There, in Portsmouth, he was able to study other work, particularly the placing of foundations and the construction of graving docks and wharves. Another happy move took him to Shropshire to supervise some house alterations for a Mr. Pulteney, the Member for Shrewsbury, and, probably through the influence of his patron, he received his first professional appointment, that of Surveyor of Public Works for the county of Shropshire.

From then on Telford's attentions were devoted to surveys, repairs to roads and bridges and the supervision of all public buildings throughout the county. During this period he studied chemistry and its application to mortars, mechanics, hydrostatics and pneumatics. In 1788 came his first recorded experience as a consulting engineer and five years later saw him firmly established as a leading figure in his profession. His life was full of activity, though nothing was scamped. At one time he was engaged on no fewer than two dozen major engineering enterprises—a remarkable tribute to his ability to recognise talent and loyalty in others and to train them to execute his orders. Thus at one time he was building canals (not only in this country but also in Sweden), roads, bridges and harbours as well as supplying clean water to several major cities. But it was bridge building that formed Telford's main enthusiasm and he well deserved the title conferred on him by a friend, that of " Pontifex Maximus." At one place he built his bridge of stone; at another he used iron, and his bridges are lasting monuments to his skill and sense of design, focusing on the genius of the man.

The kind of thinking which made him see the importance of fostering the Institution of Civil Engineers as a means of storing both knowledge and experience gave him an insight into the scope for British engineering abroad. From 1810 to 1833, he acted as adviser on the Gota Canal to the Swedish Government which was trying to break the Danish stranglehold on the mouth of the Baltic. Out of Telford's work came not only prestige for British engineering but also contracts for the supply to Sweden of engineers, machinery, cement and other equipment.

It is easy to take much of Telford's pioneer work for granted in these days—as it is in any age which can accept as axiomatic what another age has had to find out by trial and error. His insistence on the need for good roads, sound foundations and good drainage fell at first on incredulous ears. No sooner had his case been accepted by a wider public than it fell out of fashion. He ended his days during the railway boom when roads were about to pass in the popular imagination into second place for a century. Fortunately his work on pure water supply (he did much work on this at Liverpool, Edinburgh and London) was better developed by later generations.

So far as roads were concerned, Telford was both ahead of and behind his times. He dreamed of steam coaches on roads joining the larger towns. His greatest road was that between London and Holyhead, 260 miles long, constructed between the years 1810 and 1824. Like so many pioneers, his more advanced ideas did not have available for their consummation an adequate technical vehicle. Steam coaches there soon were but they ran on rails and Telford's generation had not come upon the technical possibilities of oil.

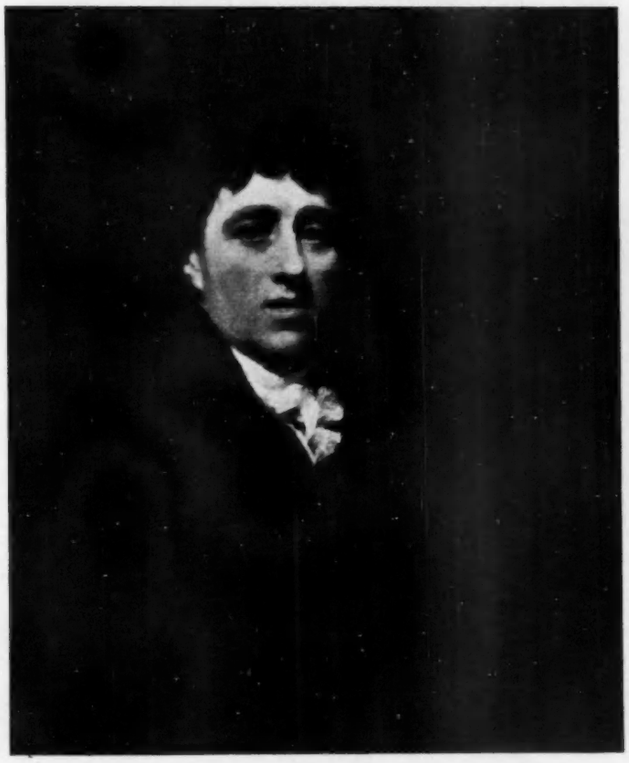
There is thus a unique aspect about the bi-centenary celebration of this pioneer of road transport. A hundred years ago the railways were completing their triumph over road and canal. To-day, the road system—though as yet starved of capital—has come back into its own and that largely at the expense of the railways. The better roads which must be built in the second half of the Twentieth Century will still owe much to the ideas of Telford.

For 50 out of 77 years Telford devoted his life to civil engineering and it can be fairly stated that he contributed as much as anyone in this sphere to enabling this country to become a commercial power and the centre of a great empire. His birth has been commemorated by two fine exhibitions, the first at the Engineering Laboratories of the University of Cambridge followed by the second at the Institution of Civil Engineers, so that there has been a display of Telfordiana almost right through the summer. Others beside Telford have travelled a distinguished road from shepherd's cottage to Westminster Abbey. But not all have had two consecutive exhibitions to mark their bi-centenary.

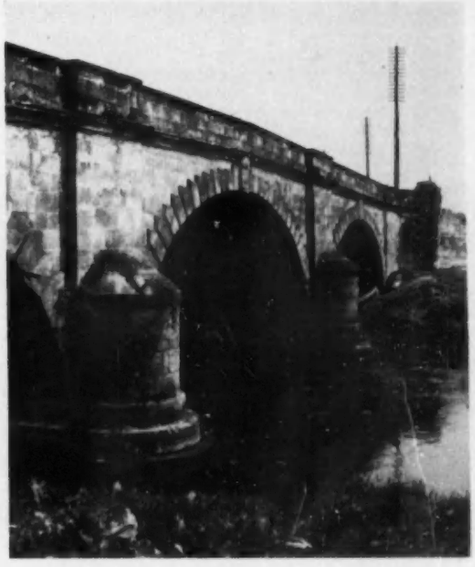
On the following two pages we depict Telford and his work. The portrait, by Sir Henry Raeburn, R.A., is part of the Lady Lever Collection, and the Trustees of the Collection have kindly given their permission for its reproduction in this article. We are also indebted to Mr. K. A. Knell, librarian in the University Department of Engineering, for making available to us a selection of illustrations, some of which are used on the following pages, and for some of the material used in the text.

Menai Suspension Bridge (1819-1826) perhaps the most famous of Telford's bridges. It has a clear span of 570 ft. The towers are built of hard grey limestone. The bridge connects the island of Anglesey with the mainland of Wales and was the most important link on the Shrewsbury to Holyhead road.

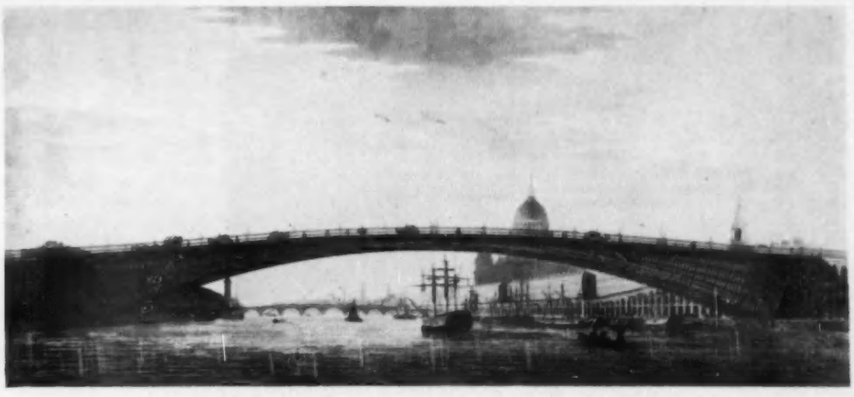
The Caledonian Canal (1803-1822) was without doubt Telford's largest single enterprise, built to be an inland coast-to-coast route for sea-going vessels. In one section, eight connected locks raised the vessels 64 ft. in a distance of 500 yards.



Thomas Telford, F.R.S., from the painting by Sir Henry Raeburn, R.A.



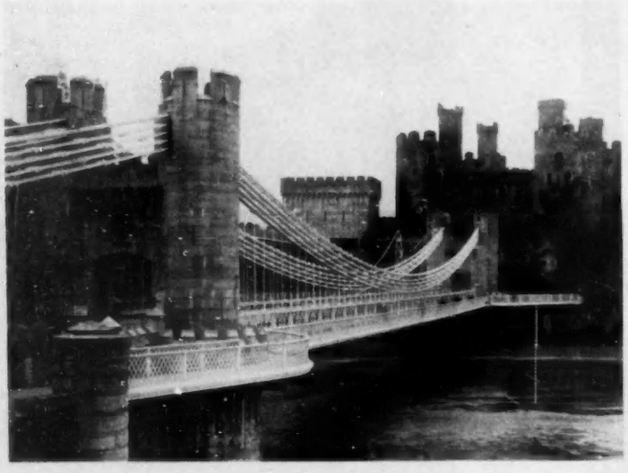
Montford Bridge (1790-1792), the first bridge designed and built by Telford. It has three elliptical arches of 55 ft., 58 ft. and 55 ft. span. It is still in use.



Proposed London Bridge (1801). This was to be a cast-iron bridge with a span of 600 ft. and would have been only the second bridge Telford had built using this material. The proposed bridge had a clearance of 65 ft. at high water.

(Left) Buildwas Bridge (1796), Telford's first iron bridge and only the second to be built in the country. It spans the River Severn and is on the road between Shrewsbury and Bridgenorth. The span is 130 ft. and only 173 tons of iron were required.

(Right) Tongueland Bridge (1805-1806) crosses the River Dee at a point of high banks and a 20 ft. tide, hence the single span. To lighten the weight—the span is 112 ft.—Telford built a series of walls parallel with the outer walls, and steadied them by T-stones instead of using a filling of earth or low-quality masonry.



(Left) Conway Suspension Bridge (1822-1826), Telford's most picturesque bridge and intended by its designer to have the appearance of a "huge drawbridge." It has a span of 327 ft. and the chains were similar to those used at Menai.

(Right) Craigellachie (1812-1815), the first modern iron arch bridge, using bracings in the spandrels. The reduction in weight compared to Buildwas is notable and gave a style that Telford was to use on several more occasions.

(Left) Dean Bridge, Edinburgh (1829-1831), which has its main springings at a height of 70 ft., the arches rising another 30 ft. Above these are the shallow arches which carry the pathways. The double construction gives an appearance of lightness and the bridge is the most impressive of Telford's masonry designs.

Letters to the Editor

OVERTIME AT HOME

SIR, You have voiced words of wisdom in formulating a truism of the undeniable evidence of men forced to work shorter hours than they want to, and having to spend their out-of-working hours on decorating, electrical installations, plumbing and the like, to keep their minds and energy employed. (Plain Words, July 19, page 66.)

The majority would prefer a six, or even a seven-day, working week, in preference to being called upon—voluntarily or involuntarily—to do tradesmen's jobs in their own homes. Undoubtedly they would prefer to pay other men to do the work for which those men are trained and be left free themselves to devote their own energies to their own jobs, and their leisure times to hobbies of enjoyment, not of economic necessity.

FRANCIS B. WILLMOTT.

108-9 Cheapside,
Birmingham 12.
July 29, 1957.

★ ★ ★

THE DESIRE FOR RECOGNITION

SIR, Your leading article about the recent declaration of policy by the Engineers' Guild is welcome, but one of your remarks may have the effect of lulling into a sense of false security those very people whom we, and perhaps you also, want to spur into action. You rightly make the point that still only a minority of the members of the Institutions of Civil, of Mechanical and of Electrical Engineers belong to the Guild, and you suggest that "out of this weakness, however, strength may grow" in that "the smaller body is more fluid and consequently can operate more decisively." Whilst this suggestion may be true in some measure, the capacity to take decisive action is inevitably limited by the extent of the Guild's resources, both financial and numerical.

Every professional engineer stands to benefit from the activities of the Guild, and particularly from the successful completion of the survey of salaries and of the public relations programme. But these are costly undertakings and it would be unwise as well as unfair if those at present outside the Guild were to rest content with their position, in the comfortable assurance that the present members would see them through. The advantages, such as they are, of a smaller body are without question outweighed by the increased strength which comes from greater numbers.

Yours faithfully,
J. G. ORR,
Secretary.

Engineers' Guild,
78 Buckingham-gate,
London, S.W.1.
July 31, 1957.

SIR, Does not your leading article of July 26 do rather less than justice—doubtless inadvertently—to the work that is being, and has for many years been done, by organisations such as the Institution of Professional Civil Servants and, in the Local Government field, by the National and Local Government Officers' Association?

In the Civil Service, as you know, there are clear regulations about the qualifications that must be held before an officer can be appointed as a professional engineer. These standards have been determined in discussion between the Institution and the Treasury, and they are maintained in that way. Any suggestion for amendment of those requirements is a matter of very careful examination and, again, of discussion with the Treasury. Certainly the Institution of Professional Civil Servants has a very lively sense of the importance of maintaining professional standards. The way this works out in the Civil Service, because of poor career prospects and low pay standards, is reflected in recruitment.

As you know, the Civil Service Commission has once again, in its annual report, commented on the fact that it gets a substantial number of applications for engineering appointments but few of the applicants are sufficiently qualified to secure a Civil Service appointment. Status is, of course, reflected in pay, and that is why the Institution is now in negotiation with the Treasury to secure substantial improvements in the pay and career prospects available to engineers.

In connection with, and in reference to, your remarks on a survey of professional incomes, may I say that this Institution secured the agreement of an eminent statistician to undertake such a survey. Unhappily, the three major Institutions in the engineering world did not feel able to give our survey their official blessing, without any implications, of course, for these learned bodies themselves. That seemed to us to be an essential thing before we could reasonably put a questionnaire to members of those bodies.

If, at any stage in the future, these bodies are prepared, if not to approve, at least to offer no objection to the use of their lists of members in this way, this Institution will be very happy to go ahead with such a survey.

Yours faithfully,
STANLEY MAYNE,
General Secretary.

The Institution of Professional Civil Servants,
Queen Anne's Chambers,
28 Broadway,
London, S.W.1.
July 30, 1957.

★ ★ ★

GEORGE STEPHENSON AND THE CIVILS

SIR, Although, in general, there is nothing to be gained by the discussion of "old, far-off, unhappy things, and battles long ago," I would suggest that the Report concerning the reason of George Stephenson's refusal to join the Institution of Civil Engineers, which you summarised in your issue of ENGINEERING dated July 26, should not be regarded as a fair presentation of the facts. Its bias is clearly shown by the omission, in its quotation from the *History of the Institution of Mechanical Engineers* of the essential words "unless, according to his biographer Samuel Smiles, he would submit a 'probationary essay as proof of his capacity as an engineer'." When we remember that, well before this time, Stephenson had completed the Manchester and Liverpool Railway with its crossing of Chat Moss, which he considered the greatest achievement of his life, and that his reputation as an engineer was world-wide, his resentment to the condition imposed on him by the Council is understandable. Moreover, Samuel Smiles, as the Report admits, stated that Robert Stephenson, who was a member of the Council at the time, had "strongly recommended" his father not to comply with the demand. In the face of this recommendation, it is difficult to understand how the writer of the Report can ask sententiously "Are we to believe that the devoted son was to acquiesce in the refusal of his fellow members of Council to grant the whim of an ageing and nationally respected father?" when it is abundantly clear that the "devoted son" was opposing the Council with all his might.

That the Council at the time contained certain implacable opponents of Stephenson is more than likely, for his activity in the development of our railway system was a severe blow to those whose interests lay in the construction of canals and roadways. On the other hand, he must have had plenty of supporters among the ordinary members for when he was adopted as the first President of the Institution of Mechanical Engineers in 1847, no less than 6 of the 9 members of the Council of the latter elected at the same time belonged also to the older Institution.

Stephenson's letter of 1847, on one ambiguous line of which the Report relies for its defence of the Council of those days, is no new discovery. It was well known to Smiles, but neither he nor any later biographer has ever regarded it as a contradiction of the generally agreed facts. Moreover, the close friendship of Smiles with the Stephensons, and his reputation for accuracy in historical matters combine to render his version of events far more trustworthy than the opinions expressed in the present Report.

Yours faithfully,
R. H. PARSONS.

Upper Hazelhurst,
Ticehurst,
Sussex.
July 31, 1957.

SIR, Your abridgement of a report on this subject by the Institution of Civil Engineers is of interest to anyone concerned with the history of engineering and technology. But in the presentation of the facts there is far too much of the "It seems probable that . . . therefore . . ." type of reasoning, as the following extracts show (my italics).

1. "... *there is no reason to suppose* that George Stephenson was at this time excluded. *There is, however, reason to believe* that he was not kindly disposed towards the most energetic of the founder members . . ."
2. ". . . when Telford submitted a report critical of Stephenson's work on the Liverpool and Manchester line, Stephenson *was probably neither endeared to the man nor inspired to become a member* of the Institution of which he was President."
3. ". . . I have however consented to become President to I believe a highly respectable mechanics' Institute at Birmingham. *To many people there will be as little doubt* that Stephenson was referring to the Institution of Civil Engineers as that he was referring to the Institution of Mechanical Engineers."
4. ". . . *if we are to believe Smiles.*"

Such woolly arguments reduce the value of this report considerably.

Yours faithfully,
REX WAILES.

386 Euston-road,
London, N.W.1.
August 1, 1957.

★ ★ ★

MACHINE FOUNDATIONS

SIR,—I was most interested to read the letter by Dr. A. J. King on the above subject, published on page 103 of ENGINEERING for July 26, and may, perhaps, emphasise that the main purpose of my own letter was to stimulate more interest in the use of resilient mounts, precisely because of the opposition from some maintenance and erection engineers, which he mentions.

However, over the last two to three years, many maintenance engineers have come to realise the disadvantages of the old method of bolting machines down, and I should like to draw attention here to a series of case histories which we have produced from time to time. These case histories will, I think, supply convincing evidence that the mounts are applicable to machines with large pulsating or oscillating forces. Customers are often surprised how effective the mounts are for presses. Many of these tools, incidentally, are far from being symmetrical, but our experience is that press applications are not only the most dramatic from the point of view of the results obtained but that they are, in general, among the easies,

Letters to the Editor (continued)

of the many different types of installations we have now successfully carried out.

Every now and again, however, we come across a " rogue " press, which either persists in moving on the floor or in rocking excessively, even though we may have carried out an entirely satisfactory installation of the same model of machine elsewhere. Investigation always shows that the cause of the difficulty is some abnormal characteristic of the press, such as a badly-balanced flywheel, a badly-worn bearing or something similar.

We have also had numerous other instances where a customer was not getting satisfactory operation from a machine tool, but did not know the reason until the machine was mounted, when the abnormal out-of-balance or other fault immediately became apparent. It will be appreciated that a machine rigidly bolted down may well be subjected to excessive stresses as a result of some fault, which will certainly have an adverse effect on its life, if not upon the quality of the work produced; whereas, if the machine be freely mounted, the abnormal forces set up as a result of the fault will result in rocking or movement instead.

Yours faithfully,
for Cementation (Muffelite) Limited,
A. S. BYTHWAY,
Managing Director.

Cementation (Muffelite) Limited,
20 Albert-embankment,
London, S.E.11.
July 29, 1957.

MACHINE FOUNDATIONS

SIR, We have read with much interest Mr. A. S. Bythway's letter, published on page 70 of your issue of July 19, regarding the above subject and would like to associate ourselves with his remarks. It may interest your readers to know that it is now possible to produce rubber mountings for the support of both heavy and light machines where the bolting down of the machine is not necessary.

Yours faithfully,
S. W. MARSH,
Technical Manager.

Andre Rubber Company Limited,
Kingston By-Pass,
Surbiton,
Surrey.
July 30, 1957.

★ ★ ★

MR. H. H. JOHNSON

It is with deep regret that we have to announce the death of Mr. Herbert Henry Johnson, M.I.Mech.E., M.I.E.E., a former Editor of ENGINEERING and a director of ENGINEERING LIMITED. Mr. Johnson died at his home at Harpenden, Hertfordshire, last Saturday, August 3, aged 82. A full obituary notice and an appreciation will be published in our next issue.

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COURSE IN PHOTOELASTICITY

Weekly lectures on the theory and methods of photoelasticity, with particular emphasis upon the use of photoelastic methods in practical stress-analysis problems, are to be held from October next to September, 1958, in the department of Civil and Municipal Engineering of University College, London. The course is suitable for workers in industrial research laboratories and for teachers in engineering colleges who desire to obtain a practical knowledge of the subject. A few places will be available for students able to spend one or two days a week on practical work in the laboratories. Applications should be made to the secretary, University College London, Gower-street, W.C.1.

Weekly Survey

Cover Picture. *Many accidents have occurred in industry as a result of objects falling from a height on to the heads of those working below. This has long been recognised in shipbuilding and in oil refineries, and even longer in the mines. Different forms of protective headgear have been developed (the hard-top bowler was one). Now the Duralumin helmet made from a pressing is becoming the more usual type of gear.*

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Commonwealth Investment

The latest White Paper dealing with the United Kingdom's investment in the Commonwealth over the years 1953 to 1956 depicts a creditable performance. It is apparent from the figures that although the money invested in the Commonwealth has not been impressive in total it has been a severe burden on this country's balance of payments. Including special assistance to certain territories, the average annual investment has been nearly £200 million, which is between 7 and 8 per cent. of the gross fixed investment programme in this country. The figure of £200 million may be compared with an average annual surplus on the balance of payments current account of about £140 million.

While the United Kingdom has maintained a modest investment programme in the Commonwealth it has been even more sparing in its investment elsewhere. At an annual average of £50 million, foreign overseas investment could hardly be said to have siphoned off considerable resources which should have gone into the Commonwealth. The trouble with a sum of about £200 million is that it is big enough to offer a little to everybody but not big enough to enable this country to finance a really big and imaginative scheme (such as the Volta River project in Ghana) without cutting down elsewhere. In this country, we have made a great deal of our willingness to do a little for everybody and to spread our resources evenly and intelligently over a vast array of colonial and dominion development schemes but there is clearly a point at which the large scheme must take priority. Kariba and the Volta have very substantial claims for inclusion in an intelligent long-term economic development plan for this country's resources in the Commonwealth when set against worthy but unimpressive projects in small backward dependencies. This is a hard saying but it is a true one.

The fact is that it takes a conscious effort on the part of the Colonial Office to prevent the large schemes getting priority in the Dominions at the expense of small schemes in the Colonies. The London money market is still the main channel of capital to the Commonwealth and the large and wealthy units must inevitably have a bigger attraction than the smaller, poorer ones. Left to the mechanism of the capital market, the Dominions would quickly attract the lion's share of such resources as are available, both in capital and technical manpower. For 13 years (the first Development and Colonial Act was passed in 1944) successive governments have pursued a policy of encouraging capital to be spread over as many territories as possible. This may still be the right policy but it is time to re-think it nevertheless.

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Sweden's Growing Challenge

Sweden has a population of only some 7 million, but (as its prestige advertising never fails to point out) it is credited by some sources as having the highest standard of living in Europe. Its people are hard working by general standards and " mechanically minded " in the sense of being intrigued with machinery. In many products, including shipbuilding and electrical engineering, its importance is growing to significant proportions.

Some of the figures published in the July issue of the *Quarterly Review* of Skandinaviska Banken show its importance for a Europe poised at the edge of the Free Trade Area. By 1956 Swedish iron ore exports (on which the United Kingdom steel industry is heavily dependent) had gone 19 per cent. above the 1950-55 annual average. On the other hand, pig-iron exports were down 16 per cent. on the same basis of comparison, while, significantly, iron and steel exports were up by 120 per cent. from a technically very progressive iron and steel industry. Paper pulp exports were about stable but paper and board exports advanced by 27 per cent. Swedish ambitions are well summed up in the Review: " . . . increased processing applied to Sweden's production for export is an essential prerequisite for an expansion of the foreign trade. Undoubtedly the relatively high tariff levels imposed on finished articles in many other countries have prevented a more rapid development in the Swedish export industries than has hitherto been attained . . . Against the background of high tariffs abroad it has seemed natural to view with some optimism the prospect of free trade within a Western European free-trade area."

There is the other side to the coin, however. Sweden is a market to be reckoned with as well as a challenger for Western European trade. Many engineering concerns might give it more attention than it has received in the past.

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Prices that were Different

It would be an easier world to live in, not the least for those on holiday, if one swallow made a summer. It is perhaps with this thought in mind that the latest *Bulletin for Industry* put out by the Treasury has an article on the few prices that fell, as opposed to the many which increased over the period 1952 to 1956. Between December, 1952, and December, 1956, there was a period of comparative international stability, apart from the Suez crisis. The Korean War was over and prices as a whole were pursuing a less dramatic but nonetheless inexorable advance to higher levels. A detailed analysis of the official wholesale price-index numbers of manufactured products shows that not all prices went up over this period, however.

The index is a compilation of 5,000 prices which are combined into 800 separate basic index numbers. An examination of these indices shows that over the period under consideration about 25 per cent. of them fell. About 12·5 per cent. of the index numbers fell by more than 6 per cent. and over a half of them increased by 6 per cent. The fall in prices was not equally spread over all products of a group. About 25 per cent. of them occurred among textiles and another 25 per cent. in chemicals. This fairly significant downward trend for these two industries is swamped in the index as a whole, however, because together they have a weight of less than 20 per cent. in the total index. Between 1952 and 1956 it is very noticeable that the price index of fuel used by manufacturing industry went up proportionately more than most other industries, by as much as 38 per cent. This increase was even larger than the rise in weekly earnings over the same period, which works out at 32 per cent. The index of prices of basic materials, excluding fuel used by non-food manufacturing industry, went up by only 5½ per cent.

The figures point to one interesting feature. The upward pressure on costs has been due mainly to higher earnings (of which higher wage rates have been an important contributory factor), and higher charges for basic materials and services. The upward pressure from the basic materials has been caused not only by their relative importance but also by a conscious changeover in public policy. Fuel and steel,

and to some extent transport, have gradually become subject to a " dear price " policy compared with the " cheap price " policy pursued by the Labour Government. To some extent, therefore, the impetus behind the pressure on costs in the last few years was a pent-up force left over from the days of official low prices, controls and subsidies.

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Heavy Engineering in India

The Indian Government have at last published the report on the establishment of a heavy engineering industry, prepared early this year, recommending the adoption of a Russian scheme in preference to proposals submitted by a British team. The Indians' decision to go ahead on the lines advocated by the Russian experts was announced last May. The fact that this was not accompanied by the publication of the committee's findings is largely explained by the contents of their report.

The committee, headed by Sir Jehangir Ghandy, of Tatas, considered the relative merits of the British and Russian plans and state quite clearly their preference for the scheme put forward by Sir Eric Coates and his team for the setting up of two separate plants, each costing Rs.33 million. They disliked the Russian proposal to concentrate the whole heavy machine building capacity in one place and thought the scale—an output of 44,000 tons for the first stage and a capital outlay of Rs.186 million—far too ambitious. Apart from its high cost, the return on such an investment would be too slow. The Russians were therefore asked to reconsider their proposals in the light of the committee's criticisms and submitted a more modest scheme, involving an investment of Rs. 70 million and an output of 22,000 tons of machinery a year at the first stage. The Ghandy committee recommended the adoption of this plan, despite their preference for de-centralised capacity, partly because the Russians gave precise indications of the types and range of the machines to be produced (based, presumably, on a survey of India's needs) whereas the British did not, and partly because the Russian scheme carried a firm offer of credit.

The Indian Government decided to ignore the committee's advice and adopted the original Russian plan, a decision which proved popular on the ground that India cannot develop her heavy industries too quickly (provided, of course, that she can get the funds) if she is to retain her political independence. This choice may not be in line with India's best interests. It is a most unfortunate one from the British point of view. It shows once again that credit is a vital aspect of overseas economic influence and, also, that industrial planning involves market studies which can never be too detailed.

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Pakistan's Five-Year Plan

The five-year plan just approved by the Government of Pakistan is expected to take the country a good deal further along the path to industrialisation. An expenditure of Rs.1,080 million (over £80 million) is envisaged which will be provided to the extent of 13 and 51 per cent., respectively, by public and private savings. The balance is expected to come from private foreign investment and external assistance.

The progress made by Pakistan in developing her economy has already been considerable. Taking 1950 as a base year, industrial production rose to 421 in 1956 and the part played by manufactured goods in the country's export drive has become most significant in the past few years, mainly jute, cotton, yarn, textiles and leather goods. They now account for 11 per cent. of the country's total earnings as against 3 per cent. two years ago. The feeling in official circles is that the rate of industrialisation could have been substantially higher " but for limited allocations of foreign exchange to industry for capital equipment, spare parts and industrial raw materials."

The shortage of capital, in an economy which was described as " totally neglected and predominantly agricultural " when the Government took over, is still likely to prove the limiting factor. The dependence on agricultural activity and on exports of agricultural produce is still considerable. Large sums are required to equip agriculture, for irrigation schemes, to improve communications and to increase the supply of energy. Progress is being made, but for many years the country must remain highly vulnerable to fluctuations in world demand for primary produce. Short of aid on a lavish scale from the International Bank, or United States funds, tight controls will remain on the import even of plant and machinery essential for the country's development.

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British Aluminium Expansion

The announcement last week that the British Aluminium Company intends to raise additional capital amounting to £5·8 million came as something of a surprise in view of the relatively short interval since the raising of £4 million in May, 1956. The extra money is required for the company's expansion projects overseas. The larger part amounting to £3·5 million is required to take up the company's 10 per cent. share in the Fria Consortium which proposes to produce 480,000 tons of alumina a year in French Guinea; Canadian British Aluminium will absorb £2 million, which represents the British company's share of additional expenditure on the Baie Comeau smelter in Quebec; and the balance, possibly with additional funds derived from current revenue, will be devoted to development of bauxite deposits in Australia in conjunction with the Consolidated Zinc Company.

In recent months the question has been raised as to whether expansion of aluminium capacity throughout the world is not proceeding too fast. Since the war world aluminium consumption has been increasing at about 12 per cent. per annum but during recent months there has been some slackening of demand in both the United States and the United Kingdom; a small surplus of production has developed in Europe and a larger surplus in the United States. Producers have attributed the European surplus in part to de-stocking by consumers who are now more confident regarding the maintenance of supplies, but the sharp fall in copper prices has removed at least part of the competitive advantage of aluminium for electrical applications. American producers can deliver surplus metal to the Government stockpile and have recently declared a surplus of 200,000 short tons for 1956.

Aluminium producers are taking the view that with the metal more freely available new uses will develop. They also point out that the main substitution of aluminium for copper took place when the latter was considerably the cheaper of the two metals and that aluminium is not likely to lose much ground at present price levels. In the United States a recent market forecast by Kaiser Aluminium and Chemical Corporation estimates that United States demand in 1965 will exceed 4 million short tons, approximately double the consumption in 1955, mainly on account of increased consumption in the building and electrical industries. If aluminium becomes competitive with tinplate the increase might be considerably larger. In this country a similar temporary oversupply developed early in 1955 but lasted only a few months. With industrial production again rising there is little doubt that in the long term the rise in consumption of aluminium will be resumed, though, in the immediate future, probably not at the same rate as in the last few years.

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Synthetic Rubber Supplies

The Board of Trade announced last week that imports of synthetic rubber into the United Kingdom in 1958 will be authorised up to the level of 80,000 tons, of which 60,000 tons will consist of GR-S general purpose rubber and the remainder of various special purpose types. The figures show no change compared with the current year but the 1958 programme will be subject to review if it is found that requirements are likely to euceed these quantities.

In 1959 some reduction in imports may be possible owing to the growth of home production but this is by no means certain in view of the rapid increase in demand, which has risen to the present level from only 8,693 tons in 1954. In the early part of this year two United Kingdom plants began the production of special purpose types: an I.C.I. plant at Wilton has a capacity of 10,000 tons of butadiene-based materials which will be used mainly in shoe soling; a Monsanto plant at Newport has a capacity of 4,000 tons. Home produced general purpose rubber will not be available until September, 1958, when the 50,000 tons plant of the International Synthetic Rubber Company, Limited, on which construction is now proceeding at Hythe, Hampshire, is expected to be completed. Mr. G. E. Beharrell, the chairman of the company, announced in May that more than 250 men were engaged on preparation of the site and on building construction and that by the end of the year £3 million would probably have been spent on the project.

Mr. H. C. Bugbee, president of the National Rubber Bureau, said in Washington recently that he expected a 77 per cent. rise in world synthetic rubber output by 1960, while natural-rubber output remains unchanged at its present level. World capacity for synthetic rubber outside the Iron Curtain countries is expected to rise from the 1956 figure of 1·28 million tons to 1·57 million tons this year, 1·83 million tons in 1958 and 2·24 million tons in 1960. If this capacity is fully utilised production of the synthetic product may slightly exceed that of natural rubber by 1959. The rapidly expanding demand for all types of rubber has, however, largely reassured producers regarding the future of the natural product and Miss N. K. Fisher, head of the Rubber and Chemicals division of the Board of Trade, was able to state recently in Kuala Lumpur that British production of synthetic rubber would not affect natural rubber purchases from Malaya.

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Science without Experiment

The scientific discoveries of recent years have been so numerous that the time may well be here when consolidation of existing knowledge may yield greater benefits than further research. Facts are available in abundance; the problem is not to gather more, but rather to discover techniques for analysing them and drawing conclusions. The mathematician has provided the necessary intellectual equipment; the computer can cope with almost any quantity of data; a new phase of technical and scientific growth may lie ahead.

Such a possibility should be examined with reserve, but in certain fields, notably chemistry, where knowledge has already an almost comprehensive quality, there is good reason to adopt an approach of this kind. In an announcement of a discussion to be presented in the B.B.C.'s Third Programme, it is quoted as the view of some scientists that " before long the chemist will have no need to experiment at all,

since computation—with the aid of electronic computers—will predict results without his having so much as to touch a test-tube." The discussion, which will be held in the series "Research" at 8.15 p.m. on August 14, will be under the chairmanship of Professor C. A. Coulson, F.R.S., Rouse Ball Professor of Mathematics, Oxford University; and three other eminent scholars will take part.

In the present century the services of the mathematician in the organisation of knowledge have been fully recognised; it appears that he is about to make a further invasion into the field of science. But whatever his success, his results can only be tested by experiment. The day of the empiricist is not yet over.

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Ships and Cargoes

The decline in shipping freights which began after the re-opening of the Suez Canal goes on unchecked. A level has now been reached when no ship but the most modern fast tonnage can operate at a profit. Although the fall has been general and has affected oil tankers as well as dry cargo ships, it has been heaviest in tramp tonnage. No substantial recovery is expected until the autumn, when the grain trade calls for substantial tonnage. The fall in freight rates was due mainly to the much reduced coal imports of Western Europe from the United States, for which large numbers of Liberty ships were employed. The present rate of 32*s.* to 33*s.* a ton on the transatlantic coal route compares with the 40*s.* to 42*s.* 6*d.* these ships require to break even.

The effect of this fall in freight rates on the ordering of new ships is unlikely to be wholly unfavourable. Any weakness in the freight market underlines the need to operate modern tonnage, and the general-purpose Liberty ship can hardly be so described. Also the concession granted by the Chancellor on investment allowances, now increased to 40 per cent. in the first year, will stimulate investment. Finally it still takes from 3 to 5 years to have a ship built almost anywhere in the world, and few would take a pessimistic view of the long-term prospects of world shipping. Another point to bear in mind is that most large operators are sheltered from heavy fluctuations in rates, either by long-term charter contracts or, when earnings are linked to the current market rates, by the operation of certain minima and maxima.

The long-term prospects of British shipping remain good. Few would subscribe to the view that there are too many oil tankers: the current rate of building is still too low (according for example to no less an authority than Mr. Niarchos) to meet replacement needs. Oil transport must increase greatly before long and coal imports from the United States to Western Europe are likely to be at a substantially higher level this year than last. Continued shortage, rather than surplus, is this winter's outlook.

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Ireland and Television

Few industries are more lively and enterprising than the radio and television industry. Achievements in world markets since the war, particularly by some of the leading companies, have been considerable. One of the most successful companies in the export field has been Pye. Their chairman, Mr. Charles O. Stanley, made an interesting and most stimulating speech to the shareholders of Pye (Ireland) Limited on July 25. He deplored the absence of a television network in the Republic of Ireland; practically every country in Europe has one, but, he said, "our country has been left out on a limb." A scheme submitted by Pye and others for setting up a television service was turned down on the ground that the country could not afford it. The proposed company, the Irish Broadcasting Company, was not registered so as not to embarrass the Government. Now, a year later, an American promoter makes a proposal to set up a television service and registers a company in the same name. Mr. Stanley has strong words to say about it: "The proposals of this American concern, as reported in the Press, are technically so fantastic, unrealistic and misleading, that we don't wish to be mentioned in the same breath in case your company should be identified with some of the ludicruous propositions that have been made."

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Falling Profits

Increases in manufacturing costs are cutting deeply into the trading profits of manufacturers of Diesel engines, despite a rising volume of output in most cases. The results of two of the leading companies in the industry, Associated British Engineering and Davey, Paxman and Company, provide a good illustration of the trend. A.B.E., whose principal engine companies are the Bergius Company, British Polar Engines, Henry Meadows and H. Widdop, report a fall in trading profits from £489,000 in 1956 to £384,000. Engine sales in terms of horsepower, on the other hand, rose by 2,000 to 289,000 b.h.p. Davey, Paxman, who make a range of Diesel engines from 100 to 2,200 b.h.p. (complementary to that of their parent company, Ruston and Hornsby) recorded a fall of £93,000 in their trading profit despite a higher output.

Both companies are expressing concern lest the rising trend of manufacturing costs should affect their competitive ability in export markets. Mr. H. Riggall, chairman of Davey, Paxman, states that the recent increase in wages in the engineering industry must mean higher selling prices. This does not affect foreign competitors to anything like the same extent and Mr. Riggall concludes that "unless we can secure stability in costs, or, what seems quite unlikely, other countries catch us up in the matter of inflation, then I fear the eventual outcome will be enforced cuts in imports or devaluation."

Mr. Lawrence Robson, chairman of A.B.E., argues in favour of wage restraint, coupled with "a measure of dividend restraint" in order to check "wage inflation ahead of genuine gains in productivity." But, Mr. Robson argues, the exceptionally high level of direct and indirect taxation in this country is likely also to be inflationary and seriously to retard progress in British industry. Thus we have two companies whose main problems are rising costs and the burden of taxation. So far both are well placed commercially and expect good results for the current year. But Mr. Riggall's remark on the need for reasonable suplus after meeting manufacturing costs and taxation, for without it "industry must inevitably shrink," is likely to prove a frequently recurring theme during the next 18 months.

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Cautious Outlook

In a short message to the shareholders of the General Electric Company, their chairman, Sir Harry Railing, advises caution. The directors recommend a reduction in the rate of dividend for the year, to 12½ per cent. payable on the increased capital of £18 million compared to 14 per cent. paid last year on a capital of £13·7 million. Sales have risen by 10 per cent. and orders received during the year, excluding the large atomic energy contract, exceeded those of the previous year by 7½ per cent. and have never been so high. Trading profits, at £9·6 million, are about £140,000 less than the year ending March, 1956.

These facts are encouraging and suggest a very satisfactory state of affairs. Yet Sir Harry Railing commented that "the further outlook depends on greater stability in the country's economic position, the necessity for which has been clearly pointed out in the Chancellor's recent statements. It is difficult at present to foresee an immediate relief from the pressure on profit margins in view of the overall effects of the further wage advances which have taken place. We also have to face further considerable development expenditure in connection with the new fields in which we are engaged, such as atomic energy and electronics."

These are views shared by most other companies likewise deeply involved in the changing nature of power production. Sir Vincent de Ferranti, chairman of Ferranti Limited, reports record orders of £21 million but a fall in profits of over 40 per cent. He also refers to increased complexity in manufacturing activities, which include digital computers, guided weapons, instruments for aircraft, machine-tool controls and a wide range of electrical and electronic equipment. Two smaller companies, Laurence Scott and Electromotors and Electric Construction Company, report continued growth and a high level of unexecuted orders. But their profits also are threatened by rising costs; nowhere is there any sign that demand for electrical machinery and equipment is falling or about to fall. The long-term prospects remain excellent for companies willing to invest in research, development and modern plant.

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Mr. R. R. Stokes

The death of Richard Stokes removes from the House of Commons not only one of its few remaining individualist characters, but also one of its few professional engineers—he was a Member of the Institution of Mechanical Engineers. After a distinguished career in the first World War, in which he gained the M.C. and bar and Croix de Guerre, he read for the Mechanical Science Tripos at Cambridge and entered the family business of Ransome and Rapiers, of which he was chairman and managing director. He was also managing director of the associated company of Cochran and Company (Annan), Limited.

More of a salesman than an engineer, he travelled extensively on behalf of his company and became, in particular, an expert on the Middle East; a fact of which Lord Attlee took advantage when he sent him to attempt to settle the Abadan oil dispute with Dr. Mosaddiq in 1951. At that time he held the specially created post of Minister of Materials, which he combined with that of Lord Privy Seal, a title which gave rise to such affectionate amusement at Ipswich that a brass plate so inscribed was affixed to a new works locomotive.

Mr. Stokes, although elected to Parliament for the Labour Party in 1938, was more of a Henry George single taxer than a Socialist, although his views on labour relations frequently made him impatient with his colleagues in the Engineering Employers Federation. No doubt his political views also prompted him, before the war, to offer to make arms without profit. Although he had previously held the office of Minister of Works, he seemed happier as an ebullient back bencher, whose boisterous interventions in favour of his own special causes sometimes infuriated, but more often delighted, the House.

Among the more unpopular of those causes were his attack on tank production during the war, for which he received the gratitude of many serving soldiers; his opposition to the bombing of Cologne; and his attempts to improve the lot of the Germans in the terrible years immediately after their defeat. Although he always said just what he thought, his frankness and courage were supported by a geniality which made him many friends on all sides. As a Roman Catholic his religion obviously played a large part in his life, but his piety was modest and balanced by his tolerance and sense of humour.

ENGINEERING FIRMS IN THE FREE TRADE AREA

6—BROWN BOVERI, SWITZERLAND

Switzerland is a country which has not yet made up its mind regarding its attitude to the Free Trade Area. It is not one of the six countries responsible for the setting up of the European Common Market but it may decide to join the Free Trade Area. Recent pronouncements by some leading Swiss industrialists have suggested that they would probably prefer to remain outside even the Free Trade Area but, in view of the dependence of the Swiss economy on the export trade and the fact that a high proportion of total exports go to European countries, this will probably prove impossible. Although Swiss exports to the United States and other American countries have increased substantially since the war, exports to O.E.E.C. member countries in Europe accounted for 55 per cent. of the total exports in the first nine months of 1956.

Machinery and clocks and watches have traditionally been the two most important categories of Swiss exports, and their importance relative to total Swiss exports has increased since the war until in 1956 machinery and transport equipment accounted for 27 per cent. of total Swiss exports by value. This compares with a figure of about 18 per cent. in 1938. A large part of Swiss machinery exports consists of machine tools, but electrical machinery and gas-turbines and other prime movers are also important. In 1956, Swiss exports of electric generators, motors and transformers were valued at Sw. Frs. 119·8 million, and had shown little change over the preceding three years. This category accounts for about one-third of total Swiss exports of electrical machinery and apparatus but, owing to lack of detail in the export returns, it is not possible to break down the balance, though in 1956 exports of electrical measuring instruments were valued at Sw. Frs. 32·4 million and of radio apparatus at Sw. Frs. 24·3 million.

LARGEST SINGLE FIRM

The A.G. Brown Boveri & Cie., with headquarters at Baden, is the leading Swiss manufacturer of electrical machinery, and, in fact, the largest single industrial enterprise in Switzerland. The company's products cover a full range of generating plant, including steam turbo-alternators, gas-turbines and complete gas-turbine installations for electricity generation; power station switchgear; transformers, circuit breakers and protection equipment; electrical drives for rolling mills and other industrial plant; electric furnaces for the metallurgical industry and electric pottery kilns; radio transmitting equipment; electric traction equipment; and turbo-compressors and turbo-chargers.

The company was founded in 1891 by C. E. L. Brown, who was of British descent, and W. Boveri, a German, and was originally concerned with electricity generating plant. The first major success was achieved in 1893 when a contract was received for a power station at Frankfurt-am-Main, for which Brown Boveri recommended alternating current although the established German electrical engineering companies had all put forward schemes based on direct current. The company were also interested from the start in electric traction and produced the electrical equipment for the first thermo-electric locomotive designed by Heilmann. In 1899 they were responsible for the first main line electrification in Switzerland on the Burgdorf-Thurn section and this was followed in 1906 by the provision of electric traction through the Simplon tunnel.

Meanwhile the company continued to pioneer in the field of electricity generation and in 1899 installed 13·5 kV generators in the Paderno d'Adda power station, the highest voltage for which generators had been built at that time. In 1901 the company built the first steam turbine on the European continent and in 1903 followed this with the first marine turbine installation to be built on the continent. In 1906 the company produced the first blast furnace turbo-blower in the world and the first turbo-compressor for gas-turbines. In 1910 they produced the Holzwarth gas-turbine and in 1917 a mechanically-driven aero-engine supercharger. In 1936 the production of high-frequency equipment was started by the company.

When production began in February, 1892, there was a labour force of 100 with 24 staff. Employment in Switzerland had reached 7,200 by 1941, and rose to 13,900 by June, 1957, but this represents only about one-quarter of the total labour force employed by the company if subsidiary and associated companies in other countries are included. The largest of these subsidiaries is Brown Boveri A.G. of Mannheim, Germany, which was founded in 1900 and now employs over 26,000 in factories at Mannheim, Gross-Auheim and Dortmund. The Cie. Electro-Mecanique, in Paris, has 9,800 employees in factories at Le Bourget, Le Havre and Lyons; Tecnomasio Italiano Brown Boveri S.A., Milan, employs 4,500 at Milan and Vado Ligure; Oesterreichische Brown Boveri-Werke A.G., 2,400 at Vienna and Steyr, and A/S Norsk Elektrisk & Brown Boveri, 1,600 at Oslo. There are also two smaller subsidiaries in America, Brown Boveri (Canada) Limited with a factory at St. Johns employing 380, and Industria Dinamo-Electrica do Brasil with 140 employees at Sao Paulo. The sales and service organisation has 167 branches spread over most of the countires of the world.

Apart from subsidiaries and associated companies, there are a number of engineering companies throughout Europe which manufacture Brown Boveri products under licence. In this country, Richardsons, Westgarth and Company, Limited, hold licences covering steam turbines, gas-turbines and other products, while Bruce Peebles and Company, Limited, hold licences to produce mutators, of which Brown Boveri first started production in 1913. In Belgium the S.A. l'Electricité Industrielle Belge hold a licence for switchgear.

The works at Baden cover an area of approximately 42 acres, and have been extensively modernised in recent years. In addition to the heavy engineering shops for the assembly of large machines and transformers and the cutting of heavy-duty precision gears, there is a separate modern factory where assembly line methods are used for the production of small motors. A new building has also recently been erected to increase capacity for turbo-charger production. In the production of high-frequency apparatus and electronic valves the company benefits from the fact that the type of skill required is closely related to that in the watch-making industry.

RESEARCH

Research is particularly important at Baden since it serves not only the Swiss factory but those of the subsidiary and associated companies.

At Baden one-quarter of the technical staff is engaged on research and testing. Among the test equipment installed are high-voltage testing installations up to 1,600 kV alternating current and 1,200 kV direct current, and high-power testing installations for generators up to 80 MVA and for transformers up to 400 kVA. For testing steam turbines there is a boiler house with a maximum high-pressure steam output of 60,000 kg. per hour at 34 kg. per sq. cm. (485 lb. per sq. in.). The company also has an aero-dynamic test department with a supersonic wind tunnel for research in connection with turbine and compressor flow problems. In order to assist in solving problems related to voltage regulation, an analogue computer has been installed.

EXPANSION PROBLEMS

In common with many electrical machinery manufacturers in other countries, Brown Boveri are finding difficulty in expanding production at a sufficient rate to meet the growing volume of orders. In 1956-57 orders in hand increased by 45 per cent. compared with the previous year. The company is therefore forced to quote long delivery dates, as a result of which a good deal of business is being lost. This state of affairs is expected to continue until a new plant is built, which has been planned for construction at Birrfield, Aargau. The company is also experiencing difficulty in recruiting adequate skilled labour or young people for training.

In order to get the best from the existing labour force and to minimise labour turnover, a merit rating scheme has been adopted. Under this scheme all workers who are paid on a time basis start with a basic hourly wage fixed according to the job. After three to ten weeks an individual hourly wage is fixed by a committee consisting of the manager of the department, the foreman, a rate fixer, a member of the company's workers' association and representatives of the accounts department and the factory management. Factors taken into account in assessing the individual hourly rate are: performance as to quantity, judged by diligence and proper use of working time; performance as to quality, judged by conscientiousness, reliability and professional knowledge; and behaviour towards fellow workers and superiors, with marks for geniality and attendance record. The merit rating of each individual is revised annually.

This scheme does not apply to pieceworkers, but a personal hourly wage is fixed for them when they start on the job and in cases where the week's output is below average there is a fall back to a guaranteed hourly wage which amounts to 80 per cent. of the personal hourly wage.

In view of the relatively small Swiss market for electrical machinery, Brown Boveri are overwhelmingly dependent on export orders. In the financial year 1956-57, 21 per cent. of the total output of the Baden factory was for the home market, 48 per cent. was exported to European countries, mainly Germany, France, Holland, Belgium, Italy and Austria, and 31 per cent. was exported to overseas countries.

VARIED PRODUCTS

Reviewing the main fields of activity of the company in the last two years, Brown Boveri and their licensees have commissioned nine steam turbo-generators of 100 MW or more and at the end of 1956 a further fourteen units were under construction. These include two 150 MW sets for the Frimmersdorf station of the Rheinisch Westfalisches Elektrizitatswerk, Essen, Germany. Complete power stations for which the company are acting as main contractors include the 250 MW Santa Barbara station which will be the largest in Italy and will utilise the brown coal deposits south of Florence. Extensions to power stations were completed during 1955 and 1956 at Smyrna, Turkey, and at Montevideo, Uruguay, while a number of small steam power stations (up to 6·25 MW) were supplied to Peru, Iraq, Mexico and Ireland.

In the field of atomic energy a company has been formed known as Reactor Limited, in which the Swiss Government has a participation, with the object of promoting the peaceful use of atomic energy. Brown Boveri, in conjunction with Sulzer Brothers and Escher Wyss, handed over to this company their plans for a heavy-water reactor for industrial research. Reactor Limited is responsible for the installation of the heavy-water reactor, together with a "swimming pool" experimental reactor supplied by the United States, at Wurenlingen, Aargau.

It is, however, in the field of gas-turbines

that the major expansion has taken place in the last two years. The first Brown Boveri gas-turbine, designed to generate 4 MW, was brought into commission in 1939. Over the period 1939 to 1954, 34 units were ordered with a total output of 228 MW, but in 1955 and 1956 some 50 machines were ordered, aggregating 734 MW. At the end of 1956 the largest gas-turbine power station in the world was that at Leghorn, comprising two 35 MW Brown Boveri units. Sets are also in operation in Switzerland, France, Spain, Luxembourg, Rumania, Iran, Saudi Arabia, Egypt, Algeria, Canada, Venezuela, Peru and Mexico.

Although the 2,000 h.p. and 2,500 h.p. gas-turbine locomotives supplied to the Swiss Federal Railways and the Western Region of British Railways proved unsuccessful owing to the high fuel consumption when idling, they led to the development of the gas-turbine mobile power station. Three of these had already been delivered by the end of 1956, each comprising a complete generating unit with an output of 6,200 kW mounted on two chassis.

TURBOCHARGERS

Turbochargers for Diesel engines constitute an important part of the company's turnover and accounted for rather over 11 per cent. of the total in 1956. Development dates back to 1925, and from then until the end of 1956 the company supplied nearly 14,000 turbochargers of various types for four-stroke engines and nearly 1,000 for two-strokes. In 1956-57 the output was 2,659 for four-stroke engines and 471 for two-strokes. In view of the large number required a system of standardised production is adopted. The number of orders divided according to the different constructional arrangements is assessed from time to time and the standardised components are manufactured and placed in stock. They are assembled about two months before the promised delivery date and are then adapted to the engine concerned.

In the field of equipment for the distribution and conversion of electricity, Brown Boveri produce a range of air-blast circuit-breakers which are exported to a large number of countries including the United States. Orders for interruptors for a simplified design of circuit-breaker have risen since their introduction in 1948 to nearly 35,000 in 1956. Other products in this field include metal-clad switchgear, isolating switches, relays and instrument transformers. Thirteen single-phase 86 MVA transformers are being supplied to the Power Authority of the State of New York for the St. Lawrence River power plant, and among other important purchasers of transformers from the company are the Swedish State Power Board, the Gougra Power Company, Switzerland, Electricité de France and the Kama testing station at Arnhem, Holland.

An important section of the company is concerned with the applications of electricity in industry, particularly the application of electric motors in various kinds of drive, and the production of induction and arc furnaces. The company was one of the pioneers in the field of electric tunnel kilns for pottery, and in 1956 supplied to the Oesterreichische Keramik A.G. a tunnel kiln 92 m. long for firing sanitary pottery and hard porcelain. The power input is 600 kW, the maximum temperature 1,410 deg. C., and the output about 10 tons per 24-hour day.

The company's interest in electric traction, which as mentioned above dates from the earliest years after its formation, has been extended to cover alternating-current traction equipment and rectifier locomotives. In 1956 Brown Boveri received an order for the electrical equipment of twelve $16\frac{2}{3}$ cycles single-phase locomotives for the Swiss Federal Railways and the contract for the erection of nine of these. The electrical equipment has also been supplied for a number of locomotives for the Austrian Federal Railways and the Federal German Railways. Development work at the present time is concerned mainly with rectifier locomotives.

As early as 1936 Brown Boveri, Mannheim, supplied a mutator locomotive for the Hollental line in Germany. More recently a mutator locomotive has been supplied to Rhein A.G. for service in the lignite mines and two further locomotives of this type are under construction for the Ste. Nationale des Chemins de Fer Francais; two mutator shunting locomotives have been ordered for the Swiss National Railways. Direct-current traction equipment is now largely confined to light railways and trolleybuses. The Italian subsidiary of Brown Boveri recently supplied much of the electrical equipment and the Brill type bogies for a set of motor coaches supplied to the Metropolitan Railway, Rome, for operation on a 1·5 kV direct-current supply; the same company also supplied the electrical equipment for the six-wheeler articulated trolleybuses for suburban traffic on the Turin-Rivoli route. In France the Cie. Electromecanique, in conjunction with the Brown Boveri head office in Baden, have supplied a number of Diesel-electric locomotives to the French Railways.

Finally, although it is not possible to mention all the activities of the company, reference must be made to high-frequency apparatus including radio relay equipment, V.H.F. radio and broadcast transmitters. F.M. multi-channel sets have been supplied to the Arabian American Oil Company and the Saudi Government Railroad among other customers. A V.H.F. radio set, type RTS, has been batch produced in large numbers and supplied, for example, to Electricité de France, the Swedish State Power Board and a number of police organisations. During the past two years a number of medium-wave, short-wave, television and F.M. V.H.F. transmitters have been supplied to Austria, India, Ireland, Yugoslavia, Holland, Mozambique, Switzerland and Vatican City.

MARKET OUTLOOK

Average earnings in Swiss industry are relatively high, hourly earnings being probably about 15 per cent. above those in the United Kingdom. Obligatory social charges are among the lowest in Europe, but even allowing for this the total cost of labour is probably higher than in any other European country with the exception of Scandinavia. This is largely a reflection of the high degree of skill involved in the principal Swiss industries particularly the watch and clock, machine tool and electrical engineering industries. That the high labour costs do not impair the competitive strength of Swiss industry is shown by the high proportion of total production which is exported—nearly 80 per cent. in the case of Brown Boveri.

In spite of the strong position held by Brown Boveri in certain fields, and their importance in the Swiss economy, total Swiss exports of electrical machinery are not large in relation to European trade. Total sales of electrical machinery, apparatus and appliances in O.E.E.C. countries in 1955 amounted to £2,420 million, of which the United Kingdom accounted for £700 million, Germany £610 million and France £530 million, these three countries accounting for over three-quarters of the total. In the first nine months of 1956 Swiss exports of electrical machinery, apparatus and appliances accounted for 4·5 per cent. of total exports from O.E.E.C. countries compared with 33·8 per cent. for the United Kingdom, 28·8 per cent. for Germany, 10·3 per cent. for Holland, 7·7 per cent. for France, and 5·3 per cent. for Belgium. In the field of machinery other than electric, Swiss exports accounted for 6·6 per cent. of the total from O.E.E.C. countries. Whether or not Switzerland decides to join the Free Trade Area cannot therefore greatly affect the overall pattern of trade.

On the other hand, it is clear that with a network of subsidiary and associated companies throughout Europe, Brown Boveri are well placed to benefit from the formation of a Free Trade Area. If Switzerland were to remain outside the Free Trade Area the company would probably be faced with the need for substantial reorganisation in view of the fact that in 1956/57, nearly half the sales of the parent company were to European countries. If these sales were to be reduced as a result of the European Common Market tariff against non-member countries, the result would probably be a further expansion of the Brown Boveri subsidiaries outside Switzerland at the expense of the Baden plant.

It would appear that the company must have a fairly strong interest in favour of Switzerland joining the Free Trade Area. Plans have already been made for the erection of a new factory in Switzerland and presumably the company have satisfied themselves that additional labour of the right type is available for this plant. It would probably be difficult to expand the German subsidiary in view of the growing shortage of labour in Germany. The possibility remains of expanding production in Italy, but the Italian company is at present one of the smallest of the Brown Boveri subsidiaries and the training of the necessary labour force to meet a really large expansion in output must inevitably take a considerable time, if in fact such an expansion could be achieved without lowering the standard of the company's products.

RESEARCH ON WELDING PROBLEMS

All engineering products are manufactured in parts which, eventually, have to be joined by one means or another, and methods of joining, therefore, play a key role in industrial production. Within the last 20 years welding has made very great strides in many industries and the pace at which this method of joining is spreading is still accelerating.

Research on all problems connected with welding is carried out by the British Welding Research Association, which originated in a committee of the Institute of Welding some years before the late war and was incorporated as a co-operative research association in 1946.

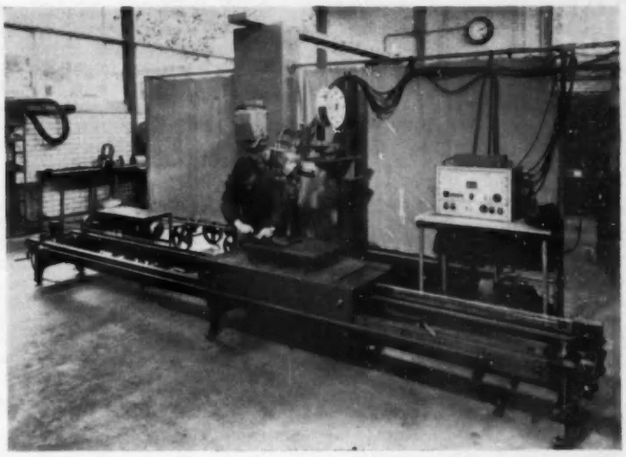
Increasing work has led to the need for larger premises and new metallurgical laboratories have been built at the Association's research station at Abington Hall, Abington, near Cambridge. To these laboratories the metallurgical research staff were transferred from 29 Park-crescent, London, W.1, in September, 1956, and the buildings were officially opened by Marshal of the Royal Air Force, Lord Tedder, on July 23. The whole of the Association's research activities are now concentrated at Abington Hall; the administration and development and publications sections alone remain at 29 Park-crescent.

The new premises have a floor area of 13,000 sq. ft., and consist of a welded portal-frame structure. The building contains a welding laboratory, equipped for manual and automatic welding; and adjacent to it, an instrument room in which observations of welding conditions can be recorded. Provision is also made for research on the welding of reactive metals and on heat flow in welding. Moreover, there are well equipped laboratories for chemical and gas analysis, metallographic examination, heat treatment and mechanical testing.

In the welding laboratory extensive use is made of automatic traversing units as these permit of better control of welding conditions than can be obtained with manual welding. A large electrically-driven traversing unit to be used in conjunction with both the controlled tungsten-arc and inert-gas metal-arc welding heads and capable of a speed range of up to 500 in. per minute, is nearly completed and is seen in the illustration on the next page. It is already in use and is now employed on an investigation of the high-current welding of aluminium. The occurrence of defective or puckered welds at currents of over 350 amperes is a serious limitation in an otherwise satisfactory process for automatic operation. The Association have

now shown that, by controlling the ingress of air to the arc and weld pool at high currents, these defects may be overcome. A special nozzle has been devised which provides extra protection to both the leading and the trailing edges of the weld pool. Well-shaped sound deposits have been made using this type of nozzle at welding currents of up to 600 amperes. The nozzle was demonstrated in our presence, satisfactorily welding 1 in. thick aluminium slabs at 500 amperes, the rate of traverse being 12 in. a minute.

Of the many research activities of the Association, which include comprehensive investigations on design, brittle fracture, fatigue testing, stress-corrosion cracking, particular welding methods and processes, gas cutting, and inspection and testing, as well as weldability, our space will allow us to mention only one other phase of the work carried on. This concerns the welding characteristics and properties of titanium and zirconium alloys. Special problems in the welding of these and other reactive metals, in the open air, are also being examined. Zirconium and titanium are readily contaminated by traces of oxygen, nitrogen and hydrogen. The properties of welds, entirely free from contamination, are obtained from test welds made in a chamber which can be evacuated to 10^{-5} mm. of mercury and filled with high-purity argon. Material for welding may be annealed or treated for hydrogen removal in a vacuum annealing furnace designed to work at temperatures of up to 1,000 deg. C., at 5×10^{-6} mm. of mercury. An autoclave has been acquired for the corrosion testing of zironcium-alloy welds in high-temperature water or steam. Open-air welding equipment comprises a traversing table having a speed range of from 0 to 70 in. per minute, perforated backing bars, a torch and a mechanised wire-feeding unit.



Automatic electrically-driven traversing unit in the welding laboratory. It is shown in use with a gas-shielded controlled-arc welding head. The traversing unit is capable of a speed range of up to 500 in. a minute.

RADIO WAVES THROUGH THE ATMOSPHERE

The importance of communication causes much effort to be spent on investigating new techniques and improving established ones. This is particularly true in radio communications. Radio waves still give the chief means of economic communication over long distances, and although a cable sometimes replaces a radio link, much research is in progress on radio systems.

The radio engineer is faced with a transmission medium with certain properties that, although variable, cannot be influenced by him. He can, however, design the terminal equipment to make optimum use of the medium, provided he has a good description of the variations to be expected. Determining the way that radio waves behave in the atmosphere forms a major part of the work at the Radio Research Station, Slough.

An account of recent work at the station appears in *Radio Research*, 1956, published by H.M. Stationery Office for the Department of Scientific and Industrial Research. The following is a summary of some of the work described.

In any quantitative description, the frequency of the radio wave must be given. Depending on their frequency, some waves are affected by the weather, or by the topography of the landscape they pass over, while others are not. The frequency decides whether the waves will be reflected by one of the ionised layers high in the upper atmosphere. If conditions are favourable transmission over large distances can be achieved by oblique reflection of the waves. If not, the waves may travel little further than the horizon.

Of the two chief regions of the atmosphere—the troposphere and the ionosphere—the propagation characteristics of the latter have received the most intense study up to recent years. However, the possibilities of very high frequency propagation through the troposphere are being realised, and it appears highly probable that greater use will be made of this form of communication.

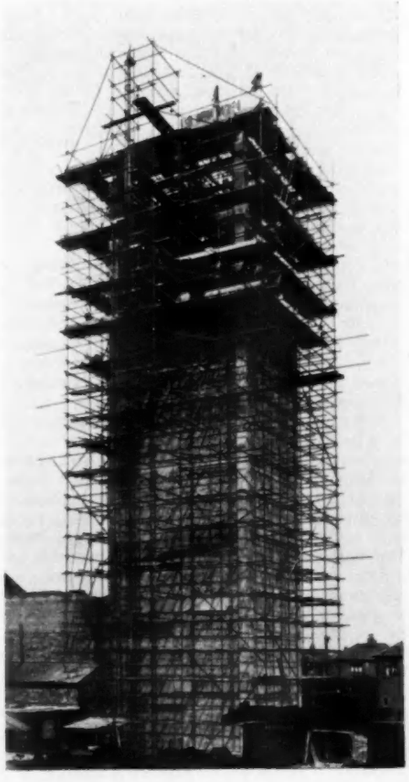
At Slough, attention has been given to the practical application of determining the transmission characteristics of the ionosphere by back scatter from the ground. In the normal method of long distance communication, the radio waves travel by means of a series of reflections between the ionised layers in the sky and the ground. The height of the layers, degree of ionisation, the frequency of the wave and its angle of incidence are all factors that decide whether communication between two given points is possible. Knowing the degree of ionisation and height of the layers, it is possible to predict the type of signal necessary to effect communication over a certain path. A disadvantage of this indirect method is that the ionospheric characteristics will probably not be constant over the path. The back-scatter technique overcomes this disadvantage by measuring the behaviour of the actual path, making use of a radar method.

The transmitter sends a signal over the path to be investigated. Each time a reflection occurs, some scattering of the incident energy takes place. The small amount of scattered energy that retraces the path of the incident ray can be detected by a receiver close to the transmitter. By measuring the time taken for the scattered signal to return it is possible to calculate the position of the reflecting layer. Generally no calculation is performed but the usual radar presentation is used to show the position of reflecting layers.

The investigation by the Radio Research Station is being undertaken at the request of the Ministry of Transport and Civil Aviation. It is designed to test the usefulness of scatter sounding as a guide to the more efficient operation of air-ground and airport-to-airport communications in the high-frequency band.

A preliminary series of observations with experimental equipment were made at Birdlip and Winstone Civil Aviation Radio Stations. Normal operational transmitters and rhombic aerials were used at Winstone, the transmitters being pulse-modulated for this purpose, while at Birdlip, five miles distant, operational rhombic aerials were connected to special receiving and display equipment.

The North Atlantic air route was investigated



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TOWER FOR TESTING TELESCOPE MIRRORS

Shown in the accompanying illustration is a 100 ft. test tower under construction by Sir Howard Grubb Parsons and Company, Limited, Walkergate, Newcastle-upon-Tyne, for carrying out optical tests on large telescope mirrors. The reflecting surface of mirrors used in telescopes has to be accurate to about 2 millionths of an inch.

Mirrors of up to 74 inches in diameter have previously been tested in a horizontal tunnel with the mirror standing on edge. This method cannot be used satisfactorily for larger sizes, and the company has therefore decided to build the new tower with a view to possible future requirements for mirrors up to 120 inches in diameter or even larger.

The tower is built upon a solid reinforced-concrete foundation, the weight of which alone is about 230 tons. It has a steel framework encased in concrete and the sides are filled in with brickwork. There are a number of internal floors each with a central hole through which the light beam may pass when the mirror is being tested. The mirror will lie at the foot of the tower, facing upwards, and the scientists carrying out the tests will be observing at the appropriate floor level. The tower walls are lined with insulating material, and careful arrangements are being made to establish constant temperature conditions in the air within the tower.

The tower is claimed to be the first of its kind in the world. For the first time it will be possible to test a mirror lying in its cell supported in the same manner as in the actual telescope.

with the equipment, the fixed circuits to Gander (Newfoundland) and New York being studied initially. The scatter information was of value in the operation of these circuits during the day, and resulted in the use of much higher frequencies than were usual, thus giving an improved signal strength and freedom from interference. The tests demonstrated clearly that scatter sounding is a valuable supplement to the means used at present for choosing operating frequencies, namely predictions of average maximum usable frequencies for each month. Apart from the direct indication of the maximum usable frequency, the modes of propagation prevailing along the route are presented visually to the operating engineer.

Further tests were carried out at night on point-to-point and air-ground communication over the North Atlantic. The results were not so simple as those got during the day: partly because of serious interference from stations on neighbouring frequencies, and partly because of the presence of complicated modes of propagation, possibly involving scattering from aurorae.

The conclusion from the preliminary tests was that the scatter sounding would be a valuable aid to civil aviation. Operational equipment has now been built for installation and routine use over an extended period.

In another experiment at Slough, observations are being made on the strength of the sound transmission from the B.B.C. television station at Kirk o'Shotts. The Slough station is some 330 miles from the transmitter—well outside the service area.

The frequency of transmission is 53·25 Mc/s. It is found that over such a distance the signal strength is dependent on the weather. During markedly anticyclonic weather the signal level is high and subject only to long-period fading that is very deep. This is taken to indicate that the propagation is chiefly by one or, at the most, two paths. On the other hand, when the transmission path is under the influence of a depression, the general signal strength is lower and the fading rapid but not so deep. Such a signal is associated with the multipath transmission that might result, for example, from some form of scattering in the troposphere.

FORWARD SCATTER

More complex conditions occur over the path between Gibraltar and Slough. The distance is a little over 1,000 miles and the path has been investigated at a frequency of 37 Mc/s. A number of different types of signal were received.

All of the time a weak signal was present. It is attributed to forward scatter in the ionosphere. Two possible mechanisms may exist to explain this type of transmission: scattering from turbulent irregularities in the ionsphere, and reflection from the large number of trails of ionisation produced by meteors of low magnitude. Experiments at Slough were directed at measuring the extent of the arc of the sky from which the signal was received, and to measure the variation of intensity over the arc. Preliminary results indicate that the mean bearing of the radiation received varies with time of day, being about 7 deg. to the west of the great-circle path at midnight and almost on the great-circle at noon. The spread of the energy in the azimuth is such that at any one time 90 per cent. of it is received from an arc of approximately $\pm$ 10 deg. about the mean azimuth.

The systematic deflection of the signal at night makes the turbulence hypothesis rather unlikely as the explanation of the night time signal. The fact that the deflection is in the same direction and about the same value as that of the strong transient signals received from meteor trails suggests that the signal may arise at night from a multitude of weak meteoric reflections.

Strong increases in signal strength occurred at brief intervals, apparently due to the effect of meteors. To give such increases the ionised trail from a meteor must be so disposed that the angle of incidence from the transmitter equals the angle of reflection towards the receiver. In addition the trail must be above the horizon of both stations. When a meteor that fulfils these conditions arrives, and provided it is heavy enough to give the needed intensity of ionisation, the signal suddenly increases to a high value and then dies away in a second or two to the background level. During the day, reflections were received most frequently from a bearing about 6 deg. to the east of the great-circle path to Gibraltar. At night the bearing changed to about 6 deg. to the west. A trend through the day such as this might be expected to arise from the effect of the orbital motion of the earth around the sun. But quantitative comparison with the distribution of sporadic meteor orbits has yet to be attempted. On the directional measurements that were made, such enhancements of signal received from Gibraltar were at the rates of a few hundred per hour at night and a few tens per hour during the afternoon.

SPORADIC E

Occasionally during daylight, and most frequently in spring and summer, a strong steady signal was received that was attributed to direct reflection from sporadic E ionisation. Sporadic E consists of layers or clouds of ionised gas at a height of about 60 miles. The layers are very thin and may be from one to several hundred miles across. No satisfactory explanation has been put forward which might account for their origin.

The field strength of the strong signal sometimes exceeded the free space value; the bearing distribution was sharp and centred on the great-circle; there was a substantial probability of the signal being steady in elevation angle for several minutes at values lying between 2½ and 8 deg., although rapid changes owing to wave interference also occurred. The magnitude of the tilt from the horizontal of the reflecting surface of the E layer, necessary to account for the range of elevation angle observed is small and would produce a quite insignificant error in bearing. The existence of reflecting surfaces with larger tilts cannot however be excluded.

In the first few months of 1956 it was found that frequency-shift telegraphy signals over the Gibraltar-Slough path were being seriously mutilated. They were often unintelligible. The transmitter was then pulse-modulated, and it became apparent that during daylight, in addition to the direct scatter signal, there were present signals delayed in time by multiples of 20 milliseconds relative to the direct signal. Up to three or four delayed signals were observed, and it is considered that these probably arose as a result of radiation, from the back of the transmitting aerial, that after one or more reflections at the F2 layer was back-scattered at the ground and then received at Slough after further reflections at the F2 layer. Sometimes a signal delayed by 140 milliseconds, relative to the direct scatter signal, has been observed—probably indicating round-the-world transmission.

TROPOSPHERIC SCATTER

The effect of aircraft flying in or near radio beams may be of importance when practical applications of scattering in the troposphere are considered. The signal level may rise by as much as 15 db over a period of about a minute. Considerable fluctuation in both the amplitude and the phase of the received signal occur owing to Doppler variations of frequency in the component reflected from the moving aircraft. These phase variations could be a serious limitation to the maximum useful bandwidths of the signal that may be transmitted by a scatter system.

Such effects were noticed during the experiments carried out between Slough and Blackwell, near Bristol, at a frequency of 1,370 Mc/s. The path length was about 90 miles and paraboloidal aerials of 3 metres aperture were used. The work was an attempt to find out how waves of this frequency were able to travel unexpectedly long distances through the troposphere. Also data were to be obtained for the development of practical communicating links operating in this manner.

The scattered signal normally received is of a very variable nature, having rapid fluctuations in level up to 15 db at the rate of one or two per second. The median value of the signal varies from hour to hour but shows no regular variation through the day; although there is a general tendency for a minimum to occur just before sunset. The median signal for a given hour of the day may vary by as much as 20 db from day to day. It was noticed that the average level of the signal increased between May and September, 1956, and thereafter decreased.

Occasionally, usually in the early hours of the morning, the rate of fading decreases whilst the depth of fading increases. At times the field strength remains relatively high and steady for periods of up to 20 minutes, and in some instances the free-space value of signal strength has been closely approached.

The nature of the propagating mechanism in the troposphere is not known. It has been suggested that the signals received far beyond the horizon are predominantly due to scattering, as a consequence of the random fluctuations of refractive index, produced by turbulence, in the lower atmosphere. There is now, however, a trend towards explanations in terms of partial reflections from one or more layers that possess a significant change in the gradient of the refractive index with height. The layers may present a rough or broken surface to incident radiation, and could thus produce the observed fading characteristics.

LONG DISTANCE SIGNALS

At somewhat lower frequencies, studies are made of propagation over large distances. In recent co-operative experiments it has been found in Japan that the pulse signals on 19·395 Mc/s from Slough are received by the great-circle route until fade-out occurs. Then they are no longer receivable. But great-circle reception of morse dots from Rugby on the same frequency continues after the Slough pulses disappear, although the signal bearing deviates in a southerly direction by as much as 130 deg. Similar behaviour has been noted on other European transmissions and the deviated signals are thought to be due to some scattering process at the ground on intermediate hops. Other paths being investigated are between Slough and Ascension Island, Bombay and Singapore.

All experiments are carried out at a fixed frequency but a variable frequency pulsed transmitter has been constructed and tested between Inverness and Slough. The transmitter frequency, which varies between 5·5 and 25 Mc/s, is stepped automatically over the range in increments of 10 kc/s, transmission on each frequency lasting for 0·4 sec. The receiver follows the transmitter tuning automatically, apart from band switching which is at present done manually. The synchronisation of all processes on both transmitter and receiver is controlled by very stable crystal clocks. The relative stability of these is such that synchronisation of the whole system may be maintained for four days without adjustment. Negotiations are now in hand to obtain a site in North Africa for further experiments over a path of about 1,500 miles.

Measurements have also been made in the very low frequency range (15-20 kc/s) to obtain detailed knowledge of the temporal and spatial variation of phase and amplitude of such waves. The programme is necessary for the successful use of very low frequency long-range navigational aids operating on a phase-comparison basis. The variable phase changes introduced by the ionosphere constitute a limitation on the accuracy attainable. The longest range studied so far is about 650 miles. The signals were provided by the Director-General of Telecommunications of Sweden and were from the Swedish station at Varberg on a frequency of 17·2 kc/s. The data obtained are at present being analysed. Other work in this frequency range is concerned with the deviation occurring when a radio wave crosses a coastline.

BRITTLE FRACTURE OF MILD STEEL IN TORSION

By J. B. Hunt, M.ENG., B.SC.(ENG.), A.M.I.MECH.E.*

In the present investigation impact tests have been made on mild-steel specimens in torsion at low temperatures in order to study the variation in stress-strain characteristics as brittle fracture conditions are approached. It was found that a uniform elasto-plastic twist existed and that this twist became a maximum when the overall ductility began to decrease. Torque-twist curves with a negative slope after yield were obtained.

The brittle fracture of mild steel has been thoroughly studied during the last decade but, as yet, there is no universally-accepted definition of brittle fracture. It has been suggested that a brittle fracture is a cleavage fracture and occurs without any prior deformation. On the other hand it has been proposed that no crack can propagate without prior deformation even though this deformation may be on a microscopic scale. It has also been shown that a cleavage fracture can take place after considerable ductility. A structural-engineering designer would not be unduly concerned concerning a material which fractured in a brittle manner after considerable ductility as he would design within the elastic limit of the material. Hence, to label such a material as being prone to brittleness, severely handicaps its usefulness. If a material could be made to fracture in a fibrous manner with little, if any, prior deformation, this material should be called brittle. Brittle means "apt to break." A material is not apt to break if there is considerable ductility before it does so. A definition of brittle fracture should therefore be based on prior deformation and not on the characteristics of the fracture face.

In the torsion-test, cleavage fractures with deformation and fibrous fractures—with little deformation—were obtained. The torsion test rather than a tensile test was chosen for two reasons. In the tensile test it is difficult to measure accurately true local strain and in the localised region where fracture occurs contraction introduces a complex three-dimensional stress system. In the torsion test, apart from a slight increase in length, the shape of the specimen remains the same; moreover, the stress-strain diagram gives a better indication of the work-hardening effect as this is not affected by large changes in dimension. True local strain in torsion and the actual strain at the fracture surface can easily be measured.

EXPERIMENTAL METHOD

Brittle fractures are usually obtained by one of three methods or a combination of the three methods. The methods comprise (*a*) causing a localised high triaxial-stress system at normal temperatures, (*b*) causing high uniaxial-straining velocities at normal temperatures and (*c*) causing normal uniaxial-straining at subnormal temperatures. The method used by the author involved the twisting of solid cylindrical steel specimens at moderately-high straining velocities at subnormal temperatures.

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The apparatus employed was similar to that used by Itihara.* It consisted essentially of a disc flywheel arranged to rotate in a horizontal plane, a spring-operated clutch designed to transfer energy from the flywheel to the specimen, and a torsional spring to which one end of the specimen was fixed. For straining rates above the normal an electric motor was used to rotate the flywheel. The specimen was enclosed in a double-walled insulated vessel. A pencil beam of light was focussed on to a mirror attached to the torsional spring so that on reflection, a light spot was formed on a screen a fixed distance from the axis of rotation of the spring. The movement of this spot was recorded by a drum camera during the test. From this record the torque at any instant during the test could be determined. The dimensions of the specimen are given in Fig. 1. A line was scribed on the curved surface of the specimen, parallel to its axis before testing, so that the strain characteristics of the surface fibres could be observed. The chemical analysis of the three steels tested are given in Table I. The specimens were machined from $\frac{1}{2}$ in. square bar in the as-rolled condition and were not subjected to any heat treatment. The test temperature, that is, the temperature of the specimen immediately before engagement of the clutch or in the case of the normal slow-speed test the temperature of the specimen throughout the test, was varied within the range + 100 deg. C. to − 195 deg. C. The flywheel speed was varied within the range 0 r.p.m., for a normal slow-speed or "static" test, to 700 r.p.m.

* M. Itihara, Technology Reports, Tohoku Imperial University, vol. II, page 105 (1933).

TABLE I.—*Analysis of Steels Tested*

Element	1	2	3
Carbon	0·165	0·150	0·140
Silicon	0·120	0·034	0·050
Sulphur	0·043	0·042	0·220
Phosphorus ..	0·012	0·012	0·012
Manganese	0·690	0·550	0·890

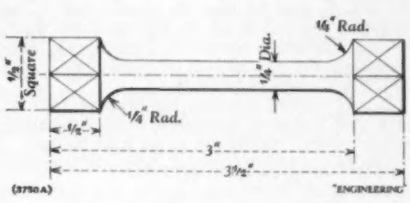


Fig. 1 Torsion-test specimen.

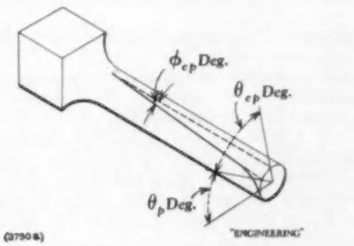


Fig. 2 Diagram showing uniform and non-uniform strain.

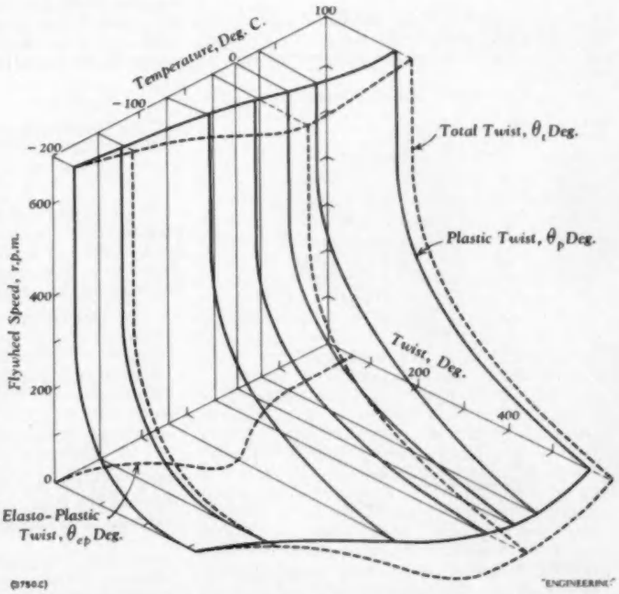


Fig. 3 Relationship between speed, temperature, and twist for steel No. 1.

RESULTS

The total twist of a specimen to fracture was made of two distinct major parts. By observing the deformation of the line scribed on the surface it was found that part of the specimen twisted uniformly and the remainder non-uniformly, as shown in Fig. 2. The uniform twist is called elasto-plastic twist θ_{ep} deg. and the non-uniform twist is called plastic twist θ_p. Fig. 3 shows the relationship between the total twist, plastic twist, temperature and flywheel speed for steel No. 1 The elasto-plastic strain

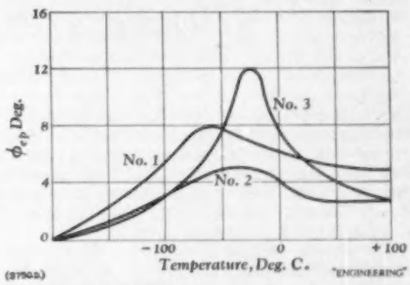


Fig. 4 Elasto-plastic strain *v.* temperature.

ϕ_{ep} could be directly measured or calculated and the fracture strain ϕ_f could be measured. Fig. 4 shows the relationship beween the elasto-plastic strain and the temperature for the three steels. From the torque-twist tests, the curves given in Fig. 5 were deduced for No. 3 steel. Each curve shown is obtained by drawing a smooth curve through points representing the average values of over one hundred tests.

DISCUSSION OF RESULTS

Fig. 3 shows that above a certain speed at each temperature the total twist is uniform. The elasto-plastic twist was found to be independent of speed and was zero at the lowest temperature. Fig. 4 indicated an increase in ϕ_{ep} deg. to a maximum value, with decrease in temperature, followed by a decrease in ϕ_{ep} deg. with further decrease in temperature. The temperature at which this maximum occurs coincides with the temperature at which the total ductility begins to decrease.

The torque-twist curves shown in Fig. 5 indicate that, within the range of speeds used in these tests, speed has an appreciable effect on ductility but little effect on the resisting torque at normal temperatures. At lower temperatures, however, it is evident that the flywheel speed has a greater effect on resisting torque between 0 and 100 r.p.m. than between 100 and 700 r.p.m. The combined effect of speed and temperature more than double the yield torque. The low-temperature dynamic graphs have a negative

slope after yield. This may indicate adiabatic instability instead of the steady isothermal state of testing.

The fracture-face temperature could not be measured by any means. A calculation of temperature could be made on an energy basis but this was considered to be inaccurate. No martensitic formation was discovered at the fracture face.

It was interesting to note that though the ductility of the specimens of a particular material varied considerably, depending on the speed and temperature of the test, the strain at the curved surface of the specimens at the fracture face remained the same for every test.

Charpy impact tests were made on steels 2 and 3. The specimens were cut with a V-notch to British Standard Specification 131:1933. The transition temperatures, i.e., the temperatures at which brittleness was first detected, were 50 deg. C. and 95 deg. C., respectively. The author is indebted to Dr. W. Steven of the Mond Nickel Company Research Department, Birmingham, for the results of these tests. The results are given in Table II.

It was noticed that on the greatest part of over five hundred specimens broken a petal-shaped pattern was found on the fracture face.

Conclusion and Acknowledgment.—Brittle fractures were obtained only at the very lowest temperature, but considerable information has been accumulated on how conditions vary up to the onset of brittleness in torsion. The cleavage fractures obtained were subjected to at least 45 deg. local plastic twist before rupture.

The author acknowledges the assistance given to him in this work by Dr. A. C. Walshaw, who is head of the Mechanical Engineering Department at the College of Advanced Technology, Birmingham.

TABLE II.—*Results of Charpy Impact Tests on Steels No. 2 and No. 3*

Steel No. 2

Specimen No.	Hardness D.P. No.	Temp. of test, deg. C.	Charpy Impact Value		Per cent. fibrous fracture
			Kg.-M	Ft.-lb.	
100		15	2·85	20½	30–35
101		−34	0·5	3½	1
102	205	60	6·85	49½	100
103		100	6·75	49·0	100
104		30	3·5	25½	55–65
105		44	3·6	26	65–70
106		51	6·3	45½	92–95
107		55	6·45	46½	99–100
108		− 3	1·15	8½	5–8
110		−23	0·6	4½	3–4
111	199	46	6·6	47½	99–100

Steel No. 3

Specimen No.	Hardness D.P. No.	Temp. of test, deg. C.	Charpy Impact Value		Per cent. fibrous fracture
			Kg.-M	Ft.-lb.	
124		15	1·65	12	25–30
125	202	−34	0·6	4½	1
126		60	2·85	20½	96–98
127		100	—	—	100
128		100	2·75	20	100
129		45	2·2	16	55–65
120		30	2·25	16	65–75
131		80	2·75	20	99
132		55	2·5	18	70–80
133		90	2·85	20½	99–100
134	209	− 3	0·85	6	10–15
135		−22	0·7	5	1–2

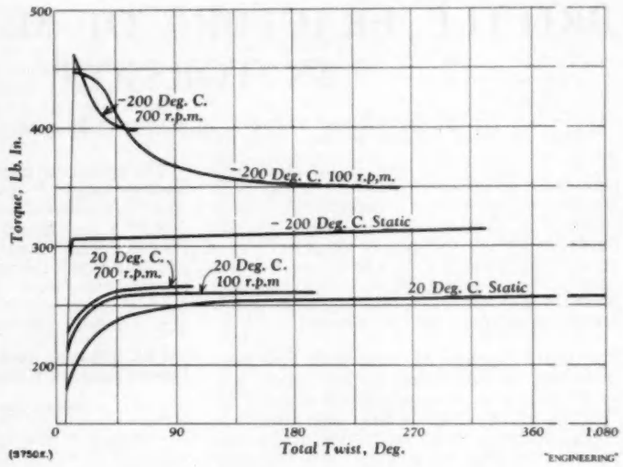


Fig. 5 Torque-twist curves for No. 3 steel.

STRESSES IN A PLATE CONTAINING A CRACK

A Theoretical Investigation *by M. Rothman**

This is a continuation of a previous article[1] in which the author considered the problem of an infinite (or large) plate containing a crack. The particular problem now being considered is that of a plate with a crack on the boundary, though the case of an infinite plate containing a multiple crack is also considered.

The general method adopted for the solution of the various problems is to transform the boundary in question on to a straight line by known transformations, or by use of the Schwartz-Christoffel transformation, and thence on to the outside of a unit circle. The original problem thus becomes that of a plate containing a circular hole under one or more boundary forces or a distributed boundary loading and, as such problems for the circular boundary have previously been solved,[2, 3] a solution of the original problem is obtained.

(1) *Crack on the Boundary of a Semi-Infinite Plate.*—It was shown by Ross and Rothman[1] that provided the plate was more than about six times the length of the crack in width, it could be considered as infinite for all intents and purposes.

The transformations

$$z = \frac{2\,i\,w^{\frac{1}{2}}}{w+1},\quad w = \frac{[1+(1+z^2)^{\frac{1}{2}}]^2}{z^2};\quad \sigma = \frac{i+w}{i-w}$$

are used to transform the cracked boundary of the z-plane into the straight line of the w-plane and thence on to the outside of the unit circle in the σ-plane.

For the first case of a wedge being forced into the crack, the complex potentials are shown to be

$$\Omega = \frac{2\,p}{\pi}\log\left(\frac{\sigma+1}{\sigma-1}\right);$$

$$w = -\frac{2\,p\,z}{\pi}\log\left(\frac{\sigma+1}{\sigma-1}\right) - \frac{4\,p}{\pi}\log z.$$

From these results the displacement and stresses at certain points are tabulated and plotted on graphs.

Secondly, the case of fluid pressure within the crack is considered. The complex potentials are given both for the case of uniform pressure over part of the boundary as well as along the crack, and over the crack only. The latter case is treated thoroughly; the potentials are shown to be

$$\Omega = 0\ ;\quad w = 4\,p\log\sigma$$

and the displacement and stresses are evaluated both at points on the line of symmetry and anywhere on the plate. These results are also plotted.

(2) *Crack on the Boundary of an Infinitely Long Plate of Finite Thickness.*—The infinitely long but finitely thick boundary containing a slit is shown to be transformed on to the straight-line boundary of the transformation

$$z = -\,b\,\frac{(a^2-1)^{\frac{1}{2}}}{\pi\,a}\left[\cosh^{-1}w - \frac{i\,\pi}{2}\right.$$

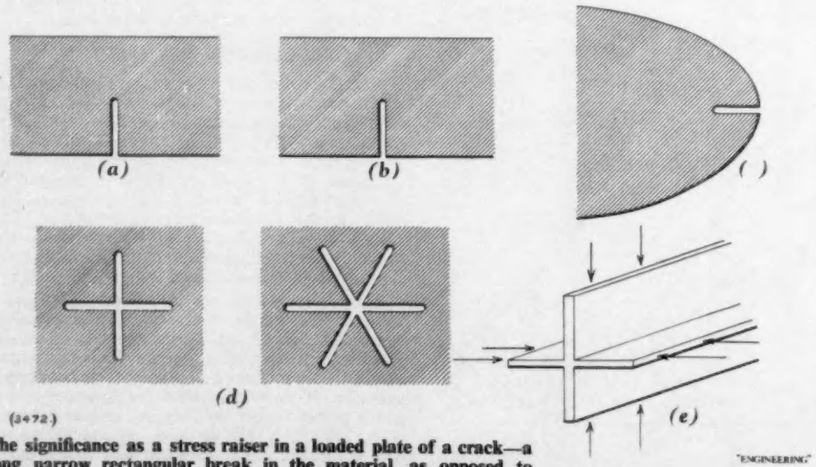
$$-\frac{a}{(a^2-1)^{\frac{1}{2}}}\cosh^{-1}\left(\frac{1}{w-a}+\frac{a}{a^2-1}\right)$$

$$\left.+\frac{a}{(a^2-1)^{\frac{1}{2}}}\cosh^{-1}\frac{1}{a\,(a^2-1)}\right] + i\,c$$

where b is the width of the boundary, c the length of the crack, and a is a suitably defined constant. The further transformation

$$\sigma = \left(\frac{i+w}{i-w}\right)$$

gives the unit circle as before.



The significance as a stress raiser in a loaded plate of a crack—a long narrow rectangular break in the material, as opposed to circular or elliptical hole—is examined using the Schwartz-Christoffel or other known transformations.

* The Northern Polytechnic, Holloway, London, N.7.

The following three cases are considered for this problem:

(*a*) uniform pressure over the crack;
(*b*) a wedge forced into the crack; and
(*c*) the problem of a tension test piece in which it is assumed that the piece is long enough compared with its width to be considered infinite.

(3) *Crack on the Boundary of a Parabolic-Shaped Plate.*—The parabolic-shaped plate with an axially directed crack at the apex is transformed on to the straight line by the transformation

$$w = \sin(a\, z^{\frac{1}{2}})$$

By further transformation on to the outside of the unit circle, the problems of a wedge being forced into the crack and of fluid pressure are considered as before, the various stresses and displacement being found.

(4) *Infinite Plate Containing a Multiple Crack.*—The final problem considered is that of an infinite plate containing a crack in the form of a "crossed slit" or, more generally, a "star-shaped" slit.

The necessary transformations are

$$w = \tan\left(\frac{\cos^{-1} z^{\frac{n}{2}}}{n}\right), \quad \sigma = \frac{i + w}{i - w}$$

where n has the value of 4 for the "crossed slit" or cruciform-shaped crack.

The cases of the plate under a state of all-round tension, for which the complex potentials are

$$\Omega(\sigma) = 2\,\mathrm{T}\,\sigma\,, \quad w(\sigma) = -\,4\,\mathrm{T}\log\sigma$$

and simple tension, at an angle $\theta = \alpha$, for which the complex potentials are found to be

$$\Omega(\sigma) = \mathrm{T}\left(\sigma + \frac{2}{\sigma}\, e^{2i\alpha}\right)$$

$$w(\sigma) = -\,\mathrm{T}\left(2\log\sigma + e^{-2i\alpha}\,\sigma^2 + \frac{e^{2i\alpha}}{\sigma^2}\right)$$

are considered, and the various displacements, etc., found.

This transformation (for the case $n = 4$) is also used to solve the problem of a girder of cruciform cross-section subject to uniform loading along opposite pairs of edges.

References

[1] M. Rothman and D. S. Ross, ENGINEERING, page 175, vol. 179 (1955).
[2] M. Rothman, *Quarterly Journal of Mechanics and Applied Mathematics*, page 279, vol. 3, Pt. 3, (1950).
[3] A. C. Stevenson, *Philosophical Magazine*, page 766, series 7, vol. XXXIV.
[4] M. Rothman, *Quarterly Journal of Mechanics and Applied Mathematics*, page 469, vol. 3, Pt. 3 (1950).

Photocopies of the full paper, of which the above is a digest, are obtainable from the Publisher, ENGINEERING, 35 & 36 Bedford Street, Strand, London, W.C.2. Price 20s each, post free.

LATERALLY LOADED PLATES

Moment Distribution around a Small Circular Hole

by Raymond Hicks, M.SC., PH.D.*

The discussion deals with the problem of a small circular hole in a laterally loaded or bent plate having some condition of constraint around its boundary. For example, a rivet hole in a simply supported plate under the action of a uniformly distributed lateral load. A general expression is obtained for the deflection surface of the perforated plate when the deflection surface of a similarly loaded plate with no hole is known. This expression has been used to find the moment distribution around holes in plates that are triangular, elliptical, circular and rectangular in plan.

It has been shown by Goodier[1] that the presence of a circular hole in an unsupported bent plate results in an increase of the maximum moment. For example, the maximum moment in a perforated rectangular plate uniformly bent about one axis is about 70 per cent. greater than the maximum moment in a similarly loaded plate with no hole.

Goodier also considered the effect of the relative size of the hole on the moment distribution in the plate. He found that when the ratio of the width of the plate to the diameter of the hole is large (say >6), the change in the moment distribution due to the introduction of the hole is local and independent of the relative size of the hole.

Reissner[2] has shown that when the diameter of a hole gets less than about three times the thickness of the plate, the classical theory for bending gives values for the tangential moment around the hole which are considerably less than the true values. These errors are due to the assumption that deflections due to transverse shear are small compared with the deflections due to bending.

In all the problems considered here it is assumed that the diameter of the hole is greater than three times the thickness of the plate so that the classical theory can be used to predict the moment distribution around the hole.

For a simply supported equilateral triangular plate bent by constant moments around its boundary, it is found that the introduction of a small circular hole at its centre of area increases the maximum moment in the region of the hole by 100 per cent. without increasing the maximum moment in the plate. This is due to the fact that the bending moments at the centre of area of an unperforated plate are considerably smaller than that which occurs at its boundary.

An expression is obtained for the tangential moment around a hole which does not necessarily occur at the centre of area of the plate. This expression is used to show that a small hole near an apex of the triangle increases the maximum moment in the plate by 77·8 per cent. when Poisson's ratio is 0·3.

For a simply supported equilateral triangular plate under the action of a uniformly distributed load, it is found that the effect of a hole at its centre of area results in a local moment which is 86 per cent. greater than the maximum moment in a similarly loaded unperforated plate. When the hole occurs at the point where the moment in a similarly loaded unperforated plate is a maximum, the effect of the hole is to increase the maximum moment in the plate by 92·2 per cent.

In the case of a hole at the centre of a uniformly loaded built-in elliptical plate, the maximum peripheral moment is greater than the maximum moment in a similarly loaded unperforated plate when the ratio of its major and minor axes is smaller than a given critical value. Above this critical value the maximum moment in the plate occurs on its boundary at the end of the minor axis. In the limit when the plate becomes circular the effect of the hole is to induce a local moment which is 100ν per cent. greater than the maximum moment in a similarly loaded unperforated plate (where ν is Poisson's ratio). An expression is obtained for the tangential moment around a hole which is not necessarily at the centre of area of the plate. This is used to show that a small hole near the end of the minor axis increases the maximum moment in the plate by $[(2 + 3\nu - \nu^2)/(3 + \nu)]$ 100 per cent.

The introduction of a non-concentric hole in a uniformly loaded simply supported circular plate results in a local moment which is greater than the maximum moment in a similarly loaded unperforated plate. This local moment increases in magnitude as the eccentricity of the hole decreases and in the limit, when the hole is concentric, reaches a value which is double the maximum moment in a similarly loaded plate with no hole.

For a simply supported rectangular plate under the action of a lateral load system, a general expression is obtained for the moment distribution around a small hole which is not necessarily at its centre of area. This expression is written in terms of a set of arbitrary constants which are determined by the distribution of the lateral load system acting on the plate. As an example, a particular load system is considered and it is found that in this case the effect of the hole is to increase the maximum moment by as much as 100 per cent. when the plate is square.

References

[1] J. N. Goodier, *Philosophical Magazine*, series 7 vol. 22, pages 69-80 (1936).
[2] E. Reissner, *Journal of Applied Mechanics, Trans. A.S.M.E.*, vol. 67, page A-69 (1945).

Photocopies of the full paper, of which the above is a digest, are obtainable from the Publisher, ENGINEERING, 35 & 36 Bedford Street, Strand, London, W.C.2. Price 25s. each, post free.

* Formerly of the Engineering Department, University of Cardiff, and now of the G.E.C.—Simon-Carves Atomic Energy Group, Fraser and Chalmers Engineering Works, Erith, Kent.

WORK STUDY IN THE R.A.F.

When work-study techniques were first applied to solving some of the problems of the Royal Air Force, the investigations were carried out by teams of investigators directly under the control of the Air Ministry. To-day, each Command of the R.A.F. has its own work-study staff which works to the requirements of the Commander-in-Chief concerned, since his is the responsibility for carrying out improvements in manpower and machines within his own Command.

This new policy has only been made possible by the education of senior staff officers and commanders in the possibilities of work study, as well as by the training of work-study specialists. Some 180 Air officers and senior civil servants, as well as 640 officers of lower rank, have now passed through a small school organised by the Director of Work Study at the Air Ministry. In addition, the "work study approach" has been introduced at the staff colleges, schools of basic training, and other courses, including those for non-commissioned officers.

How are the R.A.F. using work study? In addition to such obvious objectives as increasing the efficiency of operating and maintenance techniques, they are applying work-study methods to emergency escape drills, to the process of receiving and kitting recruits, and to "posting" procedures; already the time required to get new entrants into action at an operational station has been cut down from a day to as little as 40 minutes.

An early exercise concerned the operation and maintenance of Canberra bombers, has resulted in a 20 per cent. decrease in manpower requirements and better performance. Similar studies are now underway for the V-bomber force. By applying work study, the turn-round time (refuelling and rearming) of Hunter fighters has been reduced by about one-third, using only four men in place of ten. Many of these improvements are accompanied by ancillary savings in overheads and administrative processes which can only be assessed by business methods—and so paper-work is being streamlined and mechanised

CONTROL OF LEVEL

In this series of articles we propose to review briefly some of the methods commercially available in the United Kingdom for controlling the level of liquids and certain types of solids. Of the traditional techniques, there is to-day a very wide choice of equipment and for this reason it has not been possible to deal comprehensively with all the products on the market. It will be apparent that any method of controlling level must employ some means of level detection, and many of the items described below are designed primarily for that purpose.

The main methods of measuring level are by means of sight glasses; by floats or "displacers" partially submerged in the liquid; by measuring the pressure head of a liquid; by weighing the containing vessel; by electrical contact; by electrical capacity methods; and by the attenuation of nucleonic radiation. The reflection of sound or light beams from the liquid interface has also been used on a laboratory scale but, so far as we are aware, reflection principles have not been applied industrially in the United Kingdom. The nucleonic method is a new technique, which may have to overcome some industrial opposition on account of the radioactivity "bogey"; and the electrical methods are still comparatively newcomers and not in wide general usage yet, although they are gaining ground in "difficult" applications. As the reliability of electronic components increases, and when maintenance personnel become more familiar with the problems involved, it seems possible that these newer techniques, which eliminate any need for specific-gravity compensation will ultimately replace the well understood buoyancy and pressure-head methods that dominate the general field of liquid-level control to-day. We propose, therefore, to leave the "traditional" techniques to subsequent articles, and to commence our review with a consideration of "difficult" applications in which the more recently developed techniques offer outstanding advantages.

As regards transmission systems for remote control, it seems probable that in the process industries where inflammable and explosive mixtures are being handled, pneumatic transmission of the signals will continue to dominate the field for safety reasons. In other applications, however, electrical transmission may provide a simpler solution. In any case, electrical methods are essential for really long-distance signalling, as for instance in certain water-supply and sewage-plant applications.

1—TECHNIQUES FOR "DIFFICULT" APPLICATIONS

Certain applications, by virtue of the circumstances or the nature of the materials involved, may be regarded as "difficult." Such applications are discussed below in terms of typical "difficult" conditions.

SOLIDS

For controlling the level of solids such as granular materials, powders, and coke, an American method that is in fairly wide use is the BinDicator, comprising a vertical flexible diaphragm in the sidewall of the bin or hopper that is deflected under the lateral pressure of the solid within. In the United Kingdom, the two principal methods now on the market are based on the measurement of electrical capacity, and of the resistance offered to the passage of gamma rays, respectively. Both these methods are also well suited to the level control of corrosive fluids, since they entail no parts in contact with the fluid; and the gamma-ray technique would appear to be ideal for application to high-temperature and high or low pressure environments, since the entire measuring element is outside the fluid container. It is also readily applicable to the interface control of two liquids having substantially different densities.

The gamma-ray technique has still barely emerged from the development stages. As practised by the Baldwin Instrument Company, Limited, Dartford, Kent, a gamma-emitting isotope is placed on one side of a container, and a Geiger-Müller counter on the opposite side. The output from the detector is proportional to the amount of radiation falling on it, which will be a maximum when the contents of the vessel are below the gamma-ray beam. As the contents in the vessel rise and cut the beam, the radiation reaching the detector is substantially smaller, and the change in electrical output can be used to operate a relay, which can be incorporated in an automatic control circuit. For on-off control, two measuring heads can be fitted to the container, responding respectively to the maximum and minimum level reached by the contents, and regulating the supply accordingly. In this form a Baldwin nucleonic level indicator, similar to that shown in Fig. 1, is being installed experimentally at the Steel Company of Wales for controlling the level in the coal bunkers. The Baldwin Instrument Company also envisage a continuously indicating application, by using one source, and two detectors slightly separated from each other. Both source and detectors are mounted on travelling heads, controlled to follow the surface level by the output from the two detectors.

The Gamma Switch, seen in Fig. 2, introduced recently by Isotope Developments Limited, Aldermaston Wharf, Berkshire, is similar in principle and is claimed to be "the first inexpensive and general purpose industrial device to be based on radiation detection." It consists of a halogen-quenched Geiger-Müller tube in circuit with a simple relay, built on to a printed-circuit chassis and contained in a fireproof or weatherproof case. It is connected to a normal mains supply, and its relay contacts can be wired directly into conventional control circuits. The relay operates when a predetermined intensity of gamma radiation is detected by the Geiger-Müller tube.

An example of a suitable application of the Gamma Switch is the control of high and low level of material in a hopper. A switch is mounted at the appropriate level outside the hopper, and a gamma-ray source (suitably enclosed) is mounted on the opposite side. If the relay is set to trip when the radiation penetrating the hopper changes by the amount absorbed by the material in the hopper, a warning light or buzzer can be operated by the switch whenever the material passes the predetermined level. Alternatively, the switch can be connected to the device controlling the supply of material to the hopper, thus providing automatic control. In a similar way the switch and detector can be mounted on each side of a conveyor to give warning of a failure in supply of material on the conveyor, or on a pipeline to signal any appreciable change of density in the fluid passing through.

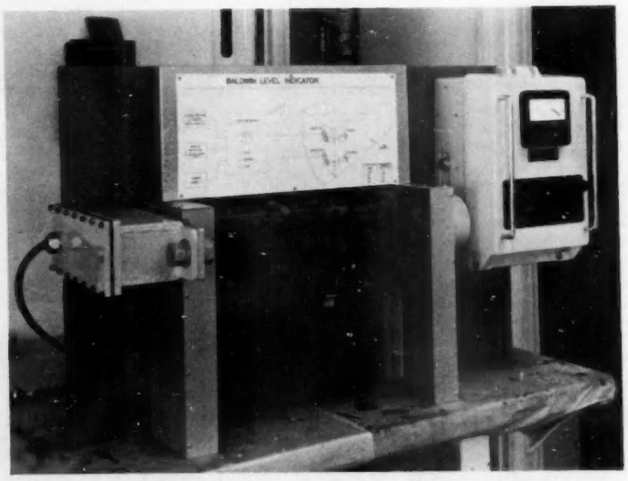


Fig. 1 Demonstration unit of a Baldwin nucleonic level indicator, here shown applied to a coke "bunker." On the left is the detector unit.

MOLTEN GLASS

An earlier application of the gamma-radiation source and Geiger-Müller detector by Isotope Developments Limited is the Installed Level Indicator, claimed to be the first commercially produced gamma-ray level gauge in the United Kingdom. Cobalt 60 is the radiation source employed. Developed in the first place specifically as an indicating and recording instrument for the measurement of the metal level in glass melting furnaces, it can readily be adapted to actuate limit contacts for on/off control or to provide pneumatic signals for operating proportional or three-term pneumatic controllers. In its simplest form the maximum range of level covered is about 3 in. with high working accuracy. Using special source and detector layouts, ranges

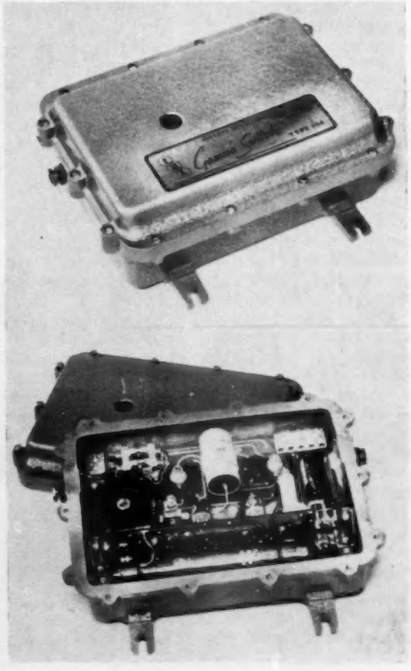


Fig. 2 The Gamma Switch, an inexpensive relay for level control, density and liquid interface detection introduced by Isotope Developments Ltd.

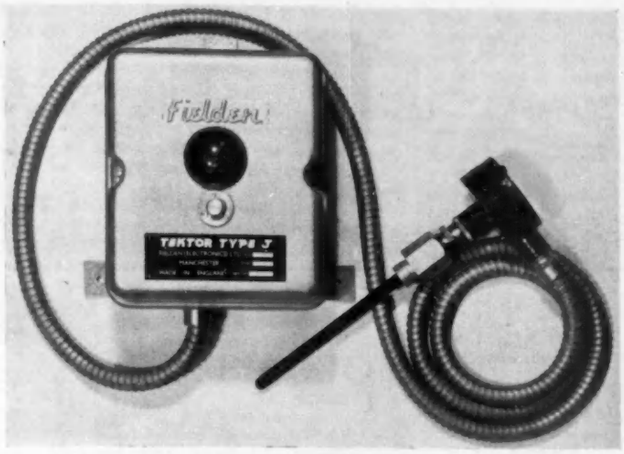
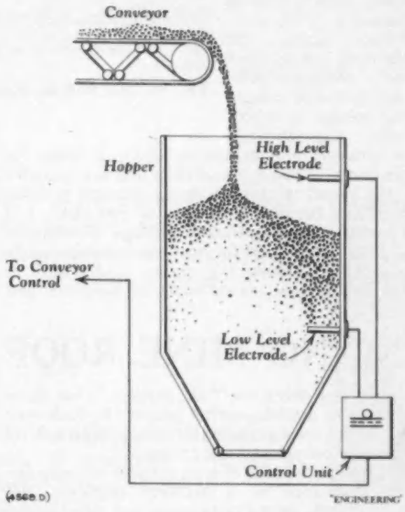


Fig. 3 (left) The Fielden Tektor level controller, which is of the proximity-switch type, comprises a capacity probe and an electronic switching unit. It is widely used in the chemical and food industries, and in mechanical handling plant for controlling the level of powders, bulky solids, slurries, oils, etc.

Fig. 4 (below) The principle of the proximity switch applied to the control of a feed conveyor in relation to hopper level. (Elcontrol)



up to 5 ft. level change can be covered. Generally the gauge will operate on vessels with internal horizontal spans up to 10 ft.

Another instrument for controlling the level of molten glass, operating in this case on the conductivity principle, utilising the molten glass as an electrolyte, is the automatic molten-glass level recorder/controller made by George Kent Limited, Luton, which was described in the December 10, 1954, issue of ENGINEERING. In this, a Multelec recorder incorporating a pneumatic controller is used to regulate the rate of batch charging; it employs two electrodes, one stationary and immersed in the molten glass, and the other a travelling electrode raised and lowered by a motor-driven gearbox. The two electrodes are energised by a low-voltage alternating-current supply so that when the travelling electrode is raised and then lowered to the point where its tip touches the glass surface, a circuit is completed energising a time-delay relay. This holds the travelling electrode stationary for a few seconds while the recorder/controller mechanism is switched into operation. After the recording has been made, the geared drive is reversed, raising the travelling electrode to the point where it breaks contact with the surface. The drive is then immediately reversed and the cycle of operation is repeated.

CAPACITORS AND PROXIMITY SWITCHES

For the control of free-flowing bulk or granular solids and powders, as well as heavy oils and viscous liquids, pulps and slurries, electrical-capacity operated instruments have been developed. They are simple to instal and the sensing element, having no moving parts, requires no maintenance. Furthermore, they are unaffected by changes in specific gravity. The aircraft industry, it is believed, were the first to adopt such instruments as indicating fuel-contents gauges (the Waymouth gauge by Smiths Aircraft Instruments Limited, Cheltenham, and the Pacitor gauge by Simmonds Aerocessories Limited, Treforest). An industrial version of the Pacitor gauge is extensively used for liquid level measurement in the chemical industry; in this instrument, the capacitor unit is immersed in the liquid and the indication is proportional to the tank contents.

The capacity-type instruments developed by Elcontrol Limited, 10 Wyndham-place, London, W.1, and Fielden Electronics Limited, Wythenshawe, Manchester, 22, on the other hand, provide on/off and not continuous, control the capacity probe generally being out of contact with the liquid.

The Tektor J on/off level controller made by Fielden Electronics Limited comprises a probe, or probes, and an electronic unit. The probe is normally inserted through the side of the container, and as the material approaches or recedes from the probe the electrical capacity changes, operating a simple electronic circuit. It is illustrated in Fig. 3.

The electronic unit employs a single valve in an oscillating circuit, the anode current of which varies with change of oscillatory amplitude. This amplitude is controlled by the effective capacity of the probe. The change of anode current is arranged to energise a relay, used, for example, to switch on or off a regulating pump or to actuate a control valve. Hence the relay is in one of two positions according to whether the material, the level of which is to be maintained, is adjacent or remote from the probe.

The instrument can be arranged to operate on a level change as small as $\frac{1}{16}$ in., or it can be set to provide a larger differential to prevent rapid intermittent action of the regulating pump or valve. The circuit is arranged to fail to safety.

Similar in principle is the Elcontrol proximity switch (Fig. 4), again comprising a capacity-operated relay unit coupled to an electrode. The capacity change necessary to operate the switch is of the order of 4pf. Single-level installations are available, comprising a relay unit containing an amplifying circuit and control relay, and a sensing unit embodying an oscillator circuit mounted in the head of the electrode. For complete high-level and low-level control, a double relay unit is available, comprising two relay units and an interlocking relay; this is used in conjunction with high and low level electrodes. Sensing units may be of the plate type or the probe type, both of which are available for heavy or light duty.

A new development released this year by Lancashire Dynamo Electronic Products Limited is their capacity-operated level control, completely transistorised and using printed-circuit techniques, which is applicable to the control of the level of a wide range of liquids, granular and powder substances in almost any type of container. The new unit, which can be seen in Fig. 5, is rugged, simple and compact and is said to be particularly easy to instal.

A number of versions will be available to meet requirements of high and low level and various combined forms of control. A common basic form of probe head is used in all applications. With much of the circuit housed in the probe head attached to the container, only two connections plus earth are needed between the head and the main unit. The maximum potential involved on the connecting cable is 12 volts with consequent safety in hazardous locations. For special applications, battery-operated versions of the equipment are available.

ELECTRICALLY CONDUCTIVE LIQUIDS

For use in electrically conductive liquids, the conductivity type of liquid level detector is less costly than the capacity-type of instrument but shares with the latter the advantages of specific-gravity independence and freedom from moving parts. Among the firms marketing instruments of this type are Elcontrol Limited, Evershed and Vignoles Limited and Fielden Electronics Limited, who have recently brought out the Aquatrol on-off controller for regulating the level of aqueous solutions, similar in principle to the Elcontrol instrument described below.

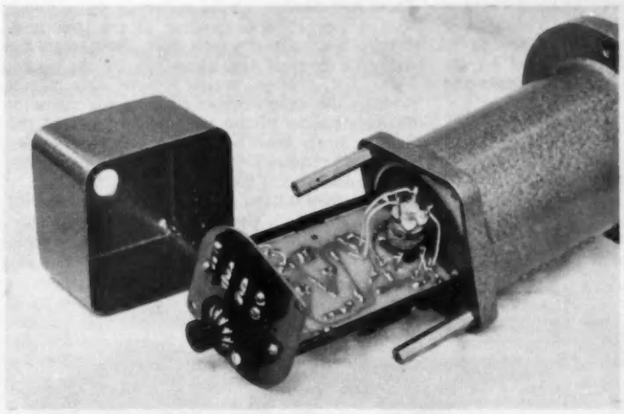


Fig. 5 Interior of the transistorised capacity-operated level control, showing the printed circuit arrangements, introduced recently by Lancashire Dynamo Electronic Products Ltd.

The Elcontrol conductive on-off level controllers, one of which is shown in Fig. 6, can be used for all conductive liquids having a specific resistance up to 20 megohms per cm. cube, and also free-flowing solids having a moisture content within the same conductivity range. Two metal probes mounted above the liquid project downwards to the high and low levels between which the liquid is to be maintained. The probes are electrically connected to a relay control unit. When the liquid makes contact with the tip of the high-level probe it completes a circuit to the control unit via earth, thus biasing the grid of a valve in the single-stage amplifier, and energising the relay which switches the pump-motor starter solenoid valve, or alarm signal as required. At the same time the relay changes over the probe connections so that the relay remains energised until the liquid falls below the tip of the low-level probe, when it is de-energised and the unit is ready for the next cycle. An alternative arrange-

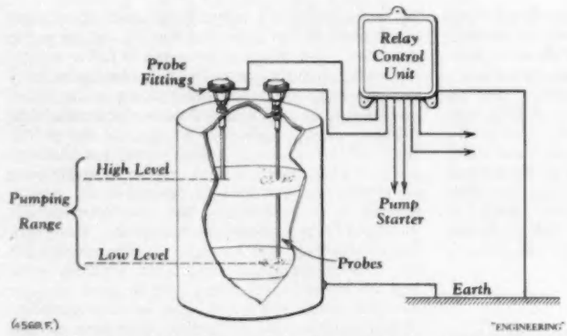


Fig. 6 Conductivity-type of level controller for electrically-conductive liquids. (Elcontrol)

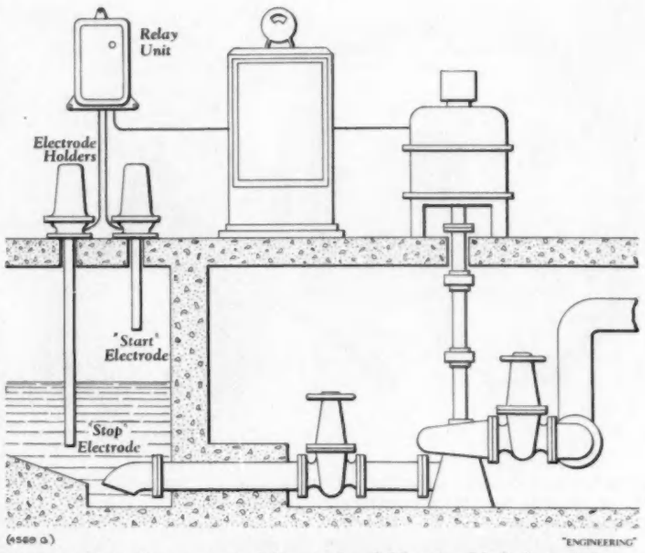


Fig. 7 The Noflote control of Evershed and Vignoles Limited applied to a drainage pump.

ment is possible in which the relay is normally energised and becomes de-energised when the liquid touches the high-level probe. A range of control units, for various sensitivities are available, and probes for various applications, suitable for open vessels, pressure vessels, open reservoirs or boreholes, etc., can be supplied.

SLUICE GATES AND PUMPS

The Noflote control by Evershed and Vignoles Limited, Acton Lane Works, Chiswick, London, W.6, primarily designed for large-scale applications such as the on/off control of pumps, sluice-gates and valves, has also been used for level control in ash-handling and coke-handling plants in generating stations and gas works. Operating from alternating-current mains, it consists essentially of high-level and low-level electrodes and a relay, the latter actuating the pilot coil of the automatic starter of the motor driving the sluice gate, pump or feed motor. A transformer isolates the electrode circuit from the alternating-current mains and reduces the voltage to a low value. The relay can be situated a considerable distance from the electrodes. Two types of relay unit are available —the standard unit operating through a water resistance between electrodes of 500 ohms, and a sensitive relay operating through a resistance of 3,000 ohms, used for instance in water-supply applications where the water conductivity is particularly low, as in parts of Scotland and Wales and in the Manchester area. The Noflote control can also be applied to level control in pressure vessels, in which case special electrodes are supplied. In general applications, users provide their own electrodes in the form of $\frac{3}{4}$ in. diameter gas piping. The unit is seen fitted to a drainage pump in Fig. 7.

To be continued

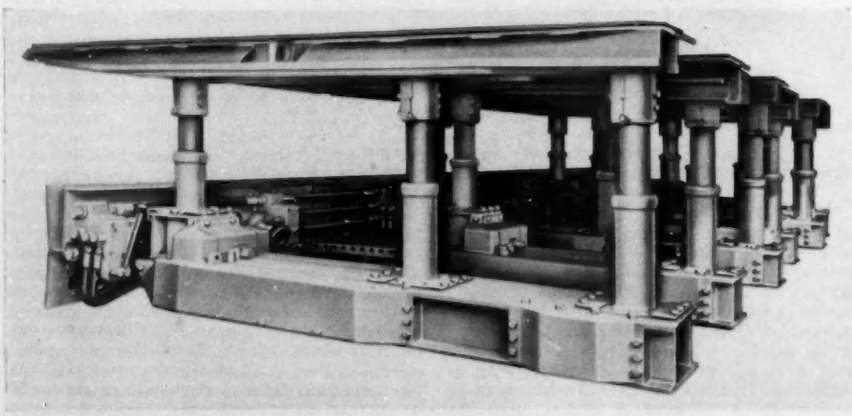
SELF-ADVANCING MINE ROOF SUPPORTS

After extensive research based on many years of experience in hydraulic roof-support systems, Dowty Mining Equipment, Limited, Ashchurch, Gloucester, have introduced a system of "self-advancing" hydraulic powered supports for fully mechanised mining, known as the "Roofmaster," in which double and triple-prop support units are released, advanced and reset by a simple valve control. Economies in manpower are effected, only three men being needed to operate a full face of Roofmasters, and greater productivity should result from the accelerated support movement.

The support units are of two types, basically similar in construction and operation, as shown in the accompanying illustration. Each comprises a box-section base, housing the hydraulic operating mechanism and into which are fitted yielding props supporting an articulated top beam. One type, known as the "fore support," incorporates two props and a twin-section top beam; the other, or "aft support," has three props and a triple-section beam. In each type the props are hydraulically linked to a control valve for pressurisation or release.

A jack in the base of each support is mechanically connected to a snaking conveyor and hydraulically linked to pressure and return lines. These are attached to the conveyor and connect with a power pack, situated at the gate end. Control valves in the pipe lines attached to the conveyor control the operation of the jacks. Fluid for proper pressurisation also passes through the valves before entering the supports through hollow piston rods. The jacks of the fore supports may be double-acting or single-acting, as required, for advancing the conveyor. All the aft support jacks are single-acting.

The system is used with a snaking conveyor on a longwall face. The supports are set immediately behind the conveyor and spaced at regular intervals to suit the roof conditions, fore and aft supports alternating. At the commencement of a cut, all supports are in line, with the roof beams set close to the face, acting as cantilever supports over the conveyor. The prop control valves are in the neutral position and the jacks of the fore supports are fully extended. The articulated roof beams ensure maximum support contact with uneven roofs and the props of all supports yield independently at 21 tons. In this way a high, even resistance is maintained along the entire face.



The Dowty Roofmaster system of self-advancing hydraulic-powered supports for coal-mine roofs is designed for use with a snaking conveyor on a longwall face.

As the power loader moves along the face, the two props of each fore support are released by selection of the prop control valve. Operation of a control valve closes the jack, drawing the support up to the conveyor. The props are then pressurised by selection of the prop control valve, bringing the roof beam up to support the newly exposed face at a setting load which can be varied up to 9 tons per prop. Both control valves are simply operated by a short removable handle carried by the operator. The valves are spring-loaded to the neutral position and selections are made against light spring pressure, eliminating accidental operation of the valves.

To "snake" the conveyor over to the new face, a selection is made at the jack control valve for the first fore support (incorporating the double-acting jack), extending the jack and pushing the conveyor forward. This simultaneously extends the single-acting jacks attached to the advancing section of the conveyor, as in the neutral position the relevant jack control valves are open to return, allowing the passage of fluid expelled from the jacks. If additional thrust proves necessary to advance the conveyor fully, the jack control valve of the first "fore" unit can be locked in the "push" position and the next double-acting jack operated.

When the conveyor is in its new position, the props of the aft support unit are released by the prop control valve. Operation of the jack control valve for the aft support causes the jack to close, drawing the support up to the conveyor. The props are then reset by the prop control valve and the roof beam supports the face

similarly to the fore support. Both supports are again in line, establishing a new caving line. This complete sequence is carried out in succession along the entire face by only three men.

The Roofmaster system provides support for the newly-exposed roof immediately the power loader has passed. The units are advanced alternately, thus maintaining the support continuously, and affording complete protection for face workers. The articulated roof beams provide maximum contact with uneven roofs, and concentration of props at the waste edge gives ideal support for total caving. The large basal areas of the supports effectively minimise floor penetration. The props are hydraulically isolated by non-return valves, and remain set in the event of a power failure.

The operation is said to be extremely rapid, a support unit being released, advanced and reset in a matter of seconds. The base members are sledged for ease of movement, and the control points are readily accessible. Valve operation is simple. A good travelling road for the power-loader team is provided, the hydraulics forming a closed circuit with no loose flexible hoses. All pipe runs are securely attached to the conveyor or boxed in the support bases. The support units are easily isolated for maintenance purposes. The jack control valve is directly accessible and the prop control valve can be readily reached by removal of a cover plate on the box base. Simplicity of construction allows very easy dismantling, and all parts liable to wear can be quickly replaced. Spares are interchangeable and do not require skilled fitting.

The standard Roofmaster caters for nominal seam heights from 3 ft. to 5 ft. Detachable extensions are provided to allow for temporary increases up to 6 in.

PNEUMATIC SUSPENSION

The advantages that might be attained by using a cushion of air instead of springs for vehicles are fairly well known. A solution to the practical problem is offered by the design that has recently been produced by the Dunlop Rubber Company, Limited, in their Engineering Components Division.

The system, which has been given the name of the "Pneuride," is shown diagrammatically in Fig. 1. As will be seen, it consists of a set of bellows, mounted near each wheel, which are fed from a central air supply. A levelling valve connected with each set automatically compensates for variation in the vehicle loading, and conventional dampers are retained. The air spring bellows are constructed of rubber and nylon cord by methods similar to those used in tyre manufacture.

As there is no inherent friction in an air spring, such as exists between the loadings of a standard elliptical or semi-elliptical spring, constant performance is assured, whether lubricated or not, and under all weather conditions. This relieves considerable strain from the shock absorbers. Some damping is contributed by inter-flow of air between the air spring and its associated air tank, reducing the amount of work taken by the shock absorbers. Moreover, the difficulties experienced by having a spring which is too stiff in the unladen condition of the vehicle are eliminated. Full spring travel for any condition of loading is assured by the control exercised by the levelling valve, and the movement of the vehicle does not depend on bump stops when fully laden or on rebound stops when travelling light. For any loading, the optimum position for the suspension is approximately the mid-point of the available travel.

The levelling valve incorporates a delay device which ensures that normal movements of short duration do not bring it into operation—that is to say, no compensation is made for movements occurring during normal running, but only for changes in height when the vehicle is being loaded or unloaded. This delay functions only during valve opening, however, closure being effected immediately the mid-point is reached. Provision has also been made to guard against damage by over-travel. If, for any reason, it is necessary to release the air from the system, the vehicle can be returned to its base riding on the rubber stops which are incorporated. Each air spring is connected to a capacity tank which increases the volume of air subjected to the deflections, thereby reducing the effective rate of the spring. The tank may be fitted at any suitable point on the chassis.

The maximum working inflation pressure is normally 100 lb. per sq. in., but in practice pressures are rarely required above 80 lb. per sq. in., a value which is readily provided by the vehicle compressor. On lighter vehicles, a replenishable container may be used. The actual quantity of air consumed is quite small, as, by reason of the delay device in the levelling valve, air is only admitted when the loading is increased. It is also claimed for air suspension that the noise level of the vehicle is considerably decreased.

Maintenance and replacement costs are claimed to be low, and can be reduced still further when the system is combined with rubber-bushed radius arms, and lubrication is entirely eliminated.

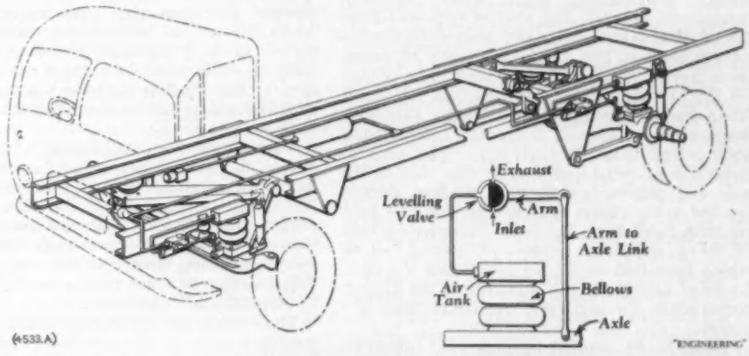


Fig. 1 (above) The Pneuride system offers virtually independent air suspension with a constant body height for any state of loading.

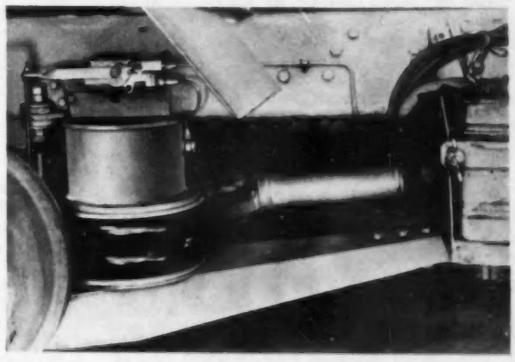


Fig. 2 (right) The bellows are made of rubber and nylon in a similar manner to tyres. Above them is the levelling valve which maintains the constant body height.

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TRAFFIC CONTROL BY TELEVISION

A permanent television installation for traffic control is to be set up in the Market Square at Durham. The equipment will allow the policeman controlling the traffic to see the number and type of vehicles waiting out of sight. At present he must control traffic he cannot see. Approval of the scheme has been expressed by Mr. Harold Watkinson, the Minister of Transport and Civil Aviation, who will make a contribution towards the cost. This method of control was tried out successfully in Durham in August, 1956.

★ ★ ★

OIL HOSE

An oil hose which is only two-thirds the weight of previous types of the same bore and working pressure is announced by the Dunlop Rubber Company, Limited. The X.L. type is a soft-walled hose without coils of solid steel wire, and is resistant to damage by kinking or rough usage. Nor is damage caused when the hose flattens under vacuum. Being made from Neoprene compounds it is resistant to oil and sun. A prototype has been subjected to sharp kinking and release tests for 1,000 cycles satistactorily. It was later pressurised to more than 1,000 lb. per sq. in.

TELEVISION ON RAIL AND ROAD

Battery-operated industrial television equipment was demonstrated recently in Switzerland by Pye Limited, Cambridge. Operating off two 12 volt car batteries in series, the equipment was shown viewing rail alignment from a moving train. Springs and other inaccessible parts could also have been viewed while the train was moving. The demonstrations were carried out to allow the Swiss Railways to assess the possibilities of the use of television to increase safety and efficiency.

The equipment was also fitted on to a *tracteur* —a small petrol-driven truck used as a service wagon. Equipped with a telephoto lens, the camera was used to examine the insulators of overhead cables for electric trains. A camera was also set up in a goods yard to relay train destination and classification marks on wagons, during both day and night, to television receivers in a viewing room.

Pye have also equipped a bus with television equipment. The lower deck of the bus is a studio and the upper deck constitutes the viewing room. Also shown is a camera on the passenger entrance platform that could allow the driver to see, on a 5 in. monitor screen, whether anyone is about to alight. The bus has recently been in Holland.

A type TL6 24 volt battery manufactured by Oldham and Son, Limited, Denton, Lancashire, powers two television cameras and two monitor screens. The battery also meets all the normal electrical power requirements of the vehicle.

Book Reviews

PIPEWORKS

Aircraft Hydraulics. Vol. 1. Hydraulic Systems. Vol. 2. Component Design. Edited by H. G. CONWAY. Published under the authority of the Royal Aeronautical Society by *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.*2. (Vol. 1, 35*s.*; vol. 2, 45*s.*)

The Aircraft Hydraulics series will be of considerable interest to anyone concerned with the design, construction, performance or maintenance of aircraft, and also of general educational value in connection with the remote control of mechanisms and the transmission of power over short distances. With the exception of part of Vol. I they are of very practical character. They give an outline of the advances that have been made in aircraft hydraulic systems since their introduction 25 years ago. The need to operate and control various services vital to the safe and satisfactory flight of modern aircraft has led to the design and development of a host of neat lightweight hydraulic components and of many ingenious systems of control, all of which have had to receive meticulous attention to detail because of the demands of the aircraft constructor for accuracy, reliability and low weight.

These books, written by men who helped to form the half-dozen or so teams of aircraft hydraulic specialists that set to work shortly before the second World War, show very clearly what has been going on in their particular field of engineering. Much credit is due to them for supplying to our aircraft constructors equipment which contributed in no small measure to the the high standard of quality of British aircraft during the war, and since. When one sees the scope and complexity of modern aircraft hydraulics and realises that behind each detail described in general terms in these volumes lies a vast amount of practical experimentation and development one cannot escape the conclusion that here is a subject which is now very much one for specialist firms. The budding aircraft designer or anyone else in need of a hydraulic control will not be induced by study of these books to attempt to design and make his own, rather will he rightly be deterred from such a course; but he will gain much useful guidance on the sort of problems and equipment involved.

At the start of Vol. I, Mr. Bingham plunges the reader straightway into the many considerations affecting fluids; the extent of underlying practical detail is at once apparent. The next two chapters by Mr. Collinson, devoted to theory, will be of interest to the designers of hydraulic systems, but their inclusion in a series of books of so practical a nature is debatable. It would perhaps have been better merely to indicate to what extent relevant theory is applied or modified in practical design and how much trial and error methods are used; and then to refer the reader to the accepted text-books. The dimensional analysis is not well injected. It is confusing, especially to the engineer, to be told that pressure, measured in lb. per sq. in., has the dimensions ML^{-2}; he usually regards it as $ML^{-1}T^{-2}$. And there is no need to bring g into the simple relation between pressure and surface tension.

Mr. Parker gives an excellent account of the different forms of aircraft hydraulic systems; he condenses a tremendous amount of useful information into 16 pages. Hydraulic circuits of many different kinds are dealt with equally efficiently by Mr. Conway.

The last two chapters by Mr. Black are full of sound practical advice to the installation and service engineer. He rightly emphasises the need for scrupulous attention to detail and points out the need to build ground test rigs as representative as possible of the airborne system. But should not such rigs include local heating and cooling jackets to represent the changes of temperature that occur in flight?

Vol. 2 begins with a survey of sealing methods. Mr. Parker here gives a very full picture of the problem of sealing and of the different kinds of seal available. Mr. Bowers follows with a useful 40 page chapter on pumps—types of pumps which have been used, analysis of performance, methods of control and off-loading, etc. His failure to mention the pump used on British aircraft more extensively than any other during the war—the Automotive Products Mark VI—is an unfortunate omission. Mr. Orloff is very informative on jacks; much ingenuity has gone into these components to give in the smallest possible space the variety of features required by the different aircraft and their various services.

Valves have been considered a large enough subject to demand two chapters. Mr. Conway has produced an interesting collection of general-arrangement drawings of selectors, showing many neat devices and designs, and Mr. Simpson's chapter covers cut-outs, relief valves, reducing valves, flow dividers, and others; an impressive array which represents a great amount of research and experiment.

Mr. Bowers has attempted much in trying to condense most of the remaining odds and ends into 15 pages; consequently, this section appears rather sketchy; but it does give the reader a glimpse of reservoirs, accumulators, pressure gauges, filters and other components. Similarly, Mr. Holland has had a difficult task in writing a very short chapter on pipes and pipe connections; less space devoted to tables of dimensions, and more to the troubles experienced and the care needed with pipes and couplings, might have been better.

The chapter by Mr. Bradbury on servo controls gives an insight into "higher hydraulics." It shows the mechanical complications of servo mechanisms and indicates briefly the kind of consideration that must be given to them in order to really understand this branch of hydraulics. The very important part played by servo-mechanisms on modern aircraft is made clear, and it is to be hoped that the chapter may induce some of its readers to study the books referred to at the end.

Summing up, these volumes can be recommended without hesitation to all aeronautical engineers as giving a comprehensive picture of what is to be found nowadays under the heading of "aircraft hydraulics." It is a large picture, full of detail and of great interest to those concerned with aircraft. To others the books will be not only educative but a useful source of reference. It is difficult to avoid overlapping when a number of people contribute to a book on a single subject, but the reader will not find much of this in the two volumes. Troubles experienced with aircraft hydraulics and their causes and cures have perhaps been a little neglected, and one could have wished for more comparisons between alternative systems and components; but these are minor criticisms. The authors are to be congratulated on the way they have presented their interesting and important subject. The writing is clear and concise and the books are well illustrated with reproductions of drawings, diagrams and photographs.

NETWORKS

The Theory of Networks in Electrical Communication and Other Fields. By F. E. ROGERS. *Macdonald and Company (Publishers), Limited*, 16 *Maddox-street, London, W.*1. (65*s.*)

Twenty-five years ago the study of electrical networks formed a negligible part of the undergraduate curriculum in many departments of electrical engineering in British universities. The theories of rotating machines, the generation and transmission of electric power and the electromagnetic field were treated in a coherent series of courses, and sometimes the theory of electronic devices was dealt with in a similar manner. At various times in these courses a student might expect to learn about Maxwell's loop currents and perhaps Thévenin's theorem and to be given some understanding of the transient responses of circuits. In a few universities the theories of the uniform transmission line and four-terminal networks were associated in a course terminating with a discussion of the properties of filters; but courses such as these were often regarded as directed specifically towards the needs of the telecommunications field. Perhaps for this reason many graduates of that period possessed a very sketchy knowledge of these topics.

Network theory had largely developed in association with developments in telecommunication, and when feedback amplifiers were introduced in the middle thirties the consequent technical changes in electrical communications were soon accompanied by a great extension of the field of network theory. During the last two decades a number of other subjects have changed so as to increase greatly their dependence on this new material. Thus a study of the analysis and design of any type of closed-loop system is hardly possible without a previous understanding of some branches of network theory: the matrix analysis of rotating electrical machines must clearly be preceded by a general study of modern methods of network analysis. Perhaps more important than the treatment of any special topic is that we now regard analyses in the time and frequency domains as being two sides of the same coin. A grasp of the relationship between these two methods is essential to the appreciation of any dynamical system, and is probably most easily acquired by a study of electrical networks.

It is now generally realised that circuit theory is a fundamental subject for all electrical engineers and that it should be presented in a coherent manner. Professor E. A. Guillemin of M.I.T. has gone so far as to describe circuit theory as "the electrical engineer's bread and butter," but in this country at least such a statement is more an expression of hope than a description of fact. "Bread" is readily available at a reasonable price, whereas no British text-books have been written on general circuit theory from a modern point of view, and the American books are generally either unsuitable or they are too expensive.

It is therefore with pleasure that one welcomes a new text-book on circuit theory, and with sadness that one realises that it is addressed almost exclusively to the student of telecommunications, but takes little account of the developments in circuit theory and telecommunications that have occurred in the last 20 years. The Laplace transform is specifically excluded and transient analysis is only treated briefly. Hence there is no discussion of time/frequency relations, or of what has become known as the "pole-zero approach" to electrical networks, and as a consequence the book is not relevant to the study of any type of closed-loop system or to general system dynamics. There is no attempt made to give a general understanding of network properties, and the foundations of network analysis are treated so as to make the book unsuitable as an introduction to matrix methods of analysis or to network synthesis. The transmission line is used as an introduction to four-terminal "lumped" networks, and hence filter theory is restricted to networks designed on an image-impedance basis, and the concept of insertion loss thus given only secondary significance.

However, it is unfair to criticise Mr. Rogers for not writing a book about other branches of

circuit theory than those covered in his text. Within his chosen field the author is generally thorough, and in many sections his treatment is more exhaustive and detailed than can be found elsewhere, but there are a number of notable omissions which reduce the usefulness of his book.

Although the principle of duality is mentioned, it is rarely used. There is no mention of nodal methods of analysis, four-terminal networks are discussed without reference to admittance parameters, and no use is made of the topographic method of obtaining dual networks. Iterative impedance and characteristic impedance are equated for symmetrical networks, but for asymmetrical structures characteristic impedance is identified with image impedance. This is likely to muddle students, especially as there is no discussion of the design of asymmetrical iterative networks, and insertion loss is only discussed in connection with image theory. Four-terminal constant-resistance networks are also ignored.

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Book Reviews

PIPEWORKS

Aircraft Hydraulics. Vol. 1. Hydraulic Systems. Vol. 2. Component Design. Edited by H. G. CONWAY. Published under the authority of the Royal Aeronautical Society by *Chapman and Hall, Limited*, 37 *Essex-street, London, W.C.2.* (Vol. 1, 35*s.*; vol. 2, 45*s.*)

The Aircraft Hydraulics series will be of considerable interest to anyone concerned with the design, construction, performance or maintenance of aircraft, and also of general educational value in connection with the remote control of mechanisms and the transmission of power over short distances. With the exception of part of Vol. I they are of very practical character. They give an outline of the advances that have been made in aircraft hydraulic systems since their introduction 25 years ago. The need to operate and control various services vital to the safe and satisfactory flight of modern aircraft has led to the design and development of a host of neat lightweight hydraulic components and of many ingenious systems of control, all of which have had to receive meticulous attention to detail because of the demands of the aircraft constructor for accuracy, reliability and low weight.

These books, written by men who helped to form the half-dozen or so teams of aircraft hydraulic specialists that set to work shortly before the second World War, show very clearly what has been going on in their particular field of engineering. Much credit is due to them for supplying to our aircraft constructors equipment which contributed in no small measure to the the high standard of quality of British aircraft during the war, and since. When one sees the scope and complexity of modern aircraft hydraulics and realises that behind each detail described in general terms in these volumes lies a vast amount of practical experimentation and development one cannot escape the conclusion that here is a subject which is now very much one for specialist firms. The budding aircraft designer or anyone else in need of a hydraulic control will not be induced by study of these books to attempt to design and make his own, rather will he rightly be deterred from such a course; but he will gain much useful guidance on the sort of problems and equipment involved.

At the start of Vol. 1, Mr. Bingham plunges the reader straightway into the many considerations affecting fluids; the extent of underlying practical detail is at once apparent. The next two chapters by Mr. Collinson, devoted to theory, will be of interest to the designers of hydraulic systems, but their inclusion in a series of books of so practical a nature is debatable. It would perhaps have been better merely to indicate to what extent relevant theory is applied or modified in practical design and how much trial and error methods are used; and then to refer the reader to the accepted text-books. The dimensional analysis is not well injected. It is confusing, especially to the engineer, to be told that pressure, measured in lb. per sq. in., has the dimensions ML^{-2}; he usually regards it as $ML^{-1}T^{-2}$. And there is no need to bring g into the simple relation between pressure and surface tension.

Mr. Parker gives an excellent account of the different forms of aircraft hydraulic systems; he condenses a tremendous amount of useful information into 16 pages. Hydraulic circuits of many different kinds are dealt with equally efficiently by Mr. Conway.

The last two chapters by Mr. Black are full of sound practical advice to the installation and service engineer. He rightly emphasises the need for scrupulous attention to detail and points out the need to build ground test rigs as representative as possible of the airborne system. But should not such rigs include local heating and cooling jackets to represent the changes of temperature that occur in flight?

Vol. 2 begins with a survey of sealing methods. Mr. Parker here gives a very full picture of the problem of sealing and of the different kinds of seal available. Mr. Bowers follows with a useful 40 page chapter on pumps—types of pumps which have been used, analysis of performance, methods of control and off-loading, etc. His failure to mention the pump used on British aircraft more extensively than any other during the war—the Automotive Products Mark VI—is an unfortunate omission. Mr. Orloff is very informative on jacks; much ingenuity has gone into these components to give in the smallest possible space the variety of features required by the different aircraft and their various services.

Valves have been considered a large enough subject to demand two chapters. Mr. Conway has produced an interesting collection of general-arrangement drawings of selectors, showing many neat devices and designs, and Mr. Simpson's chapter covers cut-outs, relief valves, reducing valves, flow dividers, and others; an impressive array which represents a great amount of research and experiment.

Mr. Bowers has attempted much in trying to condense most of the remaining odds and ends into 15 pages; consequently, this section appears rather sketchy; but it does give the reader a glimpse of reservoirs, accumulators, pressure gauges, filters and other components. Similarly, Mr. Holland has had a difficult task in writing a very short chapter on pipes and pipe connections; less space devoted to tables of dimensions, and more to the troubles experienced and the care needed with pipes and couplings, might have been better.

The chapter by Mr. Bradbury on servo controls gives an insight into "higher hydraulics." It shows the mechanical complications of servo mechanisms and indicates briefly the kind of consideration that must be given to them in order to really understand this branch of hydraulics. The very important part played by servo-mechanisms on modern aircraft is made clear, and it is to be hoped that the chapter may induce some of its readers to study the books referred to at the end.

Summing up, these volumes can be recommended without hesitation to all aeronautical engineers as giving a comprehensive picture of what is to be found nowadays under the heading of "aircraft hydraulics." It is a large picture, full of detail and of great interest to those concerned with aircraft. To others the books will be not only educative but a useful source of reference. It is difficult to avoid overlapping when a number of people contribute to a book on a single subject, but the reader will not find much of this in the two volumes. Troubles experienced with aircraft hydraulics and their causes and cures have perhaps been a little neglected, and one could have wished for more comparisons between alternative systems and components; but these are minor criticisms. The authors are to be congratulated on the way they have presented their interesting and important subject. The writing is clear and concise and the books are well illustrated with reproductions of drawings, diagrams and photographs.

NETWORKS

The Theory of Networks in Electrical Communication and Other Fields. By F. E. ROGERS. *Macdonald and Company (Publishers), Limited*, 16 *Maddox-street, London, W.*1. (65*s.*)

Twenty-five years ago the study of electrical networks formed a negligible part of the undergraduate curriculum in many departments of electrical engineering in British universities. The theories of rotating machines, the generation and transmission of electric power and the electromagnetic field were treated in a coherent series of courses, and sometimes the theory of electronic devices was dealt with in a similar manner. At various times in these courses a student might expect to learn about Maxwell's loop currents and perhaps Thévenin's theorem and to be given some understanding of the transient responses of circuits. In a few universities the theories of the uniform transmission line and four-terminal networks were associated in a course terminating with a discussion of the properties of filters; but courses such as these were often regarded as directed specifically towards the needs of the telecommunications field. Perhaps for this reason many graduates of that period possessed a very sketchy knowledge of these topics.

Network theory had largely developed in association with developments in telecommunication, and when feedback amplifiers were introduced in the middle thirties the consequent technical changes in electrical communications were soon accompanied by a great extension of the field of network theory. During the last two decades a number of other subjects have changed so as to increase greatly their dependence on this new material. Thus a study of the analysis and design of any type of closed-loop system is hardly possible without a previous understanding of some branches of network theory: the matrix analysis of rotating electrical machines must clearly be preceded by a general study of modern methods of network analysis. Perhaps more important than the treatment of any special topic is that we now regard analyses in the time and frequency domains as being two sides of the same coin. A grasp of the relationship between these two methods is essential to the appreciation of any dynamical system, and is probably most easily acquired by a study of electrical networks.

It is now generally realised that circuit theory is a fundamental subject for all electrical engineers and that it should be presented in a coherent manner. Professor E. A. Guillemin of M.I.T. has gone so far as to describe circuit theory as "the electrical engineer's bread and butter," but in this country at least such a statement is more an expression of hope than a description of fact. "Bread" is readily available at a reasonable price, whereas no British text-books have been written on general circuit theory from a modern point of view, and the American books are generally either unsuitable or they are too expensive.

It is therefore with pleasure that one welcomes a new text-book on circuit theory, and with sadness that one realises that it is addressed almost exclusively to the student of telecommunications, but takes little account of the developments in circuit theory and telecommunications that have occurred in the last 20 years. The Laplace transform is specifically excluded and transient analysis is only treated briefly. Hence there is no discussion of time/frequency relations, or of what has become known as the "pole-zero approach" to electrical networks, and as a consequence the book is not relevant to the study of any type of closed-loop system or to general system dynamics. There is no attempt made to give a general understanding of network properties, and the foundations of network analysis are treated so as to make the book unsuitable as an introduction to matrix methods of analysis or to network synthesis. The transmission line is used as an introduction to four-terminal "lumped" networks, and hence filter theory is restricted to networks designed on an image-impedance basis, and the concept of insertion loss thus given only secondary significance.

However, it is unfair to criticise Mr. Rogers for not writing a book about other branches of

circuit theory than those covered in his text. Within his chosen field the author is generally thorough, and in many sections his treatment is more exhaustive and detailed than can be found elsewhere, but there are a number of notable omissions which reduce the usefulness of his book.

Although the principle of duality is mentioned, it is rarely used. There is no mention of nodal methods of analysis, four-terminal networks are discussed without reference to admittance parameters, and no use is made of the topographic method of obtaining dual networks. Iterative impedance and characteristic impedance are equated for symmetrical networks, but for asymmetrical structures characteristic impedance is identified with image impedance. This is likely to muddle students, especially as there is no discussion of the design of asymmetrical iterative networks, and insertion loss is only discussed in connection with image theory. Four-terminal constant-resistance networks are also ignored.

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PRECISION COMPARATOR FOR SMALL CYLINDERS

DIAMETERS UP TO 1 IN., ACCURACY ± 0·000,01 IN.

By J. C. Evans, B.SC., PH.D. *and W. F. Atkins*, A.M.I.MECH.E.*

The instrument to be described was designed at the National Physical Laboratory to meet the need for a simple comparator which would enable the diameters of small cylinders to be measured by a simple technique to an accuracy within ± 0·000,01 in. It may be regarded as a development of the N.P.L.-type bench micrometer[1] designed some eighteen years ago or, indeed, of the much earlier micrometer carriage of the N.P.L.-type screw-diameter-measuring machine.[2] The bench micrometer comprises a large-thimble micrometer head and a fiducial indicator mounted collinearly in a U-shaped frame, the work being measured by placing it between the non-rotating flat-ended spindle of the micrometer head and a parallel flat anvil attached to the indicator. It can be used generally to an accuracy of ± 0·000,05 in.; with care and by repeating observations at different positions along the micrometer screw, an accuracy of ± 0·000,02 in. may be attained. It appeared likely that the finer accuracy might be achieved without duplication of observations by introducing a 10-to-1 precision wedge which would be driven by the micrometer spindle and which, in turn, would drive an anvil to contact the work. In this way, the effect of the inherent errors of the micrometer screw, both progressive and periodic, would be reduced tenfold and the magnification, that is, the ratio of the length of unit division on the micrometer thimble to displacement of the anvil, increased tenfold. To realise these advantages to the full, however, it would also be necessary to increase substantially the sensitivity of the fiducial indicator.

Accordingly, an instrument on these lines was constructed at the Laboratory primarily for the purpose of measuring accurately the diameters of cylinders used in measuring the effective diameters of screw plug gauges.[3] These cylinders range in size from 0·005 to 0·2 in. and a set of standard cylinders covering this range is provided for use with the instrument. The sizes of these standards are known to a few millionths of an inch from measurements made in the Sears Millionth Comparator.[4] In this latter machine, the measurements are made under several different measuring forces and the size of the standard under zero measuring force is determined by extrapolation. In the instrument described in this paper, the measuring force is about 8 oz. weight, but this force is common to both work and standard, so that the true diameters of the thread-measuring cylinders, i.e., the diameters in the uncompressed condition, are determined—a point of some importance in the British practice for measuring screws.[5]

The comparator is shown in Fig. 1. The various components are mounted on a base casting, the upper surface of which is sloped at about 30 deg. to the horizontal for convenience in operating the instrument. The work (a thread-measuring cylinder in the illustration) is measured between two parallel flat anvils. The upper anvil is rigidly attached to the plunger of the fiducial indicator, seen at the top of the illustration; the lower anvil is driven by a precision wedge mounted within the rectangular dust-proof housing, the wedge being driven by the micrometer head on the right. The position of the fiducial indicator can be adjusted to accommodate cylinders of different sizes. A total measuring range of 1 in. is thus provided, and the adjustable table may be used for supporting the larger work during its measurement. Details of the various components of the instrument are set out below.

Micrometer Head.—The micrometer head is a standard commercial product complying with the relevant British Standard (B.S. 1734: 1951). It has a non-rotating flat-ended spindle with a range of travel of 1 in. The pitch of the micrometer screw is 40 threads per inch and the scale on the thimble, which has a diameter of 2½ in., has 25 figured divisions each sub-divided into ten parts; each sub-division thus represents 0·0001 in. travel of the micrometer spindle and the magnification is 300 approximately. The corresponding movement of the lower measuring anvil (which contacts the work) is 0·000,01 in. on account of the 10-to-1 wedge, so that the overall magnification is about 3,000.

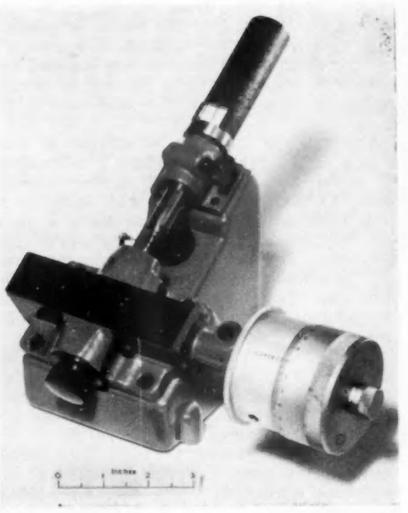


Fig. 1 In the precision comparator, the work is placed between flat parallel anvils, one of which is attached to an adjustable fiducial indicator of magnification 1,000; the other is driven by a 10-to-1 wedge moved by the micrometer head on the right.

Coupling Between Micrometer Spindle and Wedge.—The coupling between the micrometer spindle and the wedge is a flexible one. The U-shaped body *a* of the coupling (Fig. 2) is of mild steel and is attached to the wedge *b* by means of a cold-setting resin, such as Araldite. A steel ball pressed lightly into a central hole in the body contacts an end face of the wedge, and serves to transmit the thrust between the micrometer spindle and the wedge when the micrometer is advanced. Two thin spring-steel strips *s*, *s*, attached to the body of the coupling and sprung lightly into a peripheral groove ground in the micrometer spindle, enable the wedge to be towed when the micrometer is retracted. This form of coupling allows the wedge to take its location from the ball seatings provided (see below) and introduces no additional constraints when the wedge is being driven by the micrometer, a feature found essential for the successful functioning of the instrument.

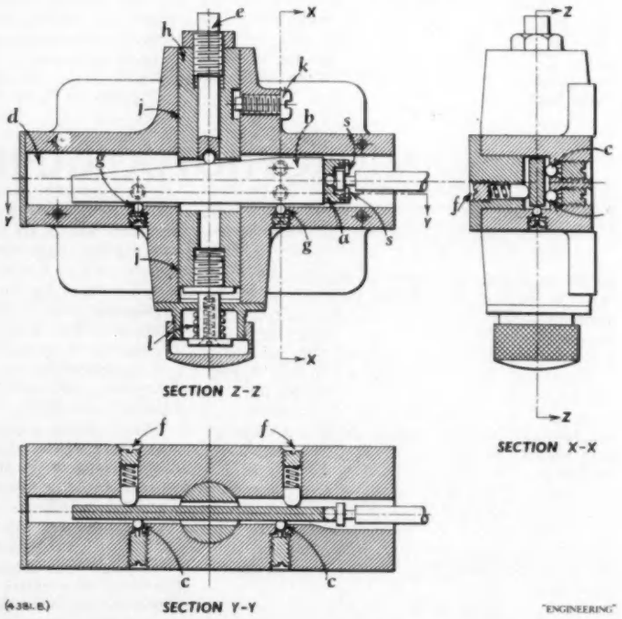


Fig. 2 Section through the comparator, showing the wedge, the lower measuring angle, and the micrometer coupling.

Wedge.—The wedge *b*, which has a taper of 1 in 10 along its length, is made of tungsten carbide. It was given the simplest possible form to facilitate machining, and its working surfaces were ground and lapped to the required angle to about 1 second of arc in order that an exact 1 to 10 conversion factor could be applied to the micrometer readings.

The wedge is supported on three balls *c*, lightly pressed into holes in the bottom of the slot *d*. The positions of these balls are initially adjusted by means of the screws provided so that contact between the lower measuring anvil *e* and the working face of the wedge is made centrally along a line of greatest slope. Two spring-loaded plungers *f* in the cover-plate can be adjusted to exert just sufficient force to ensure that the wedge is held in contact with the balls. Two further balls *g* provide the reaction to the thrust of the measuring anvil and guide the wedge in its displacements.

The sleeve *h*, which carries the lower measuring anvil *e*, is a good sliding fit in the bearings *j*. It is slotted to allow the wedge to pass through it with ample clearance and the screw *k* prevents it from rotating. The anvil is screwed into the sleeve and is of such length that a ball inserted in its lower end protrudes into the slot to make contact with the wedge. The pressure at the contact is controlled by the force applied by a suitable spring *l* located between the lower end of the sleeve and a flange screwed to the casting. This force, acting on the working face of the wedge, has a component which assists when the wedge is towed by retracting the micrometer spindle.

Fiducial Indicator.—The indicator is mounted in a small casting attached to the main base of the instrument. The bore in this casting was lapped to provide a good sliding fit for the bearing shank of the indicator. Its axis was made collinear with the axis of the lower measuring anvil, so that alignment would be preserved over the 1 in. measuring range, and a tangent bolt serves to lock the indicator in any desired position without disturbing the alignment. The mechan-

* National Physical Laboratory.

ism of the indicator is on the lines of a fiducial indicator described earlier by Rolt and Turner[6] for use in a screw-diameter-measuring machine, but modified to give a plunger-to-pointer magnification of 1,000 approximately. This is lower than the combined magnification (3,000) of the micrometer and wedge but there is an advantage on the side of the indicator in that the setting is made line-to-line. As was mentioned earlier, the upper measuring anvil has been made integral with the plunger of the indicator.

Measuring Anvils.—The contact faces of the two measuring anvils were lapped flat and parallel in situ. The anvils shown in Fig. 1, which are intended for measuring thread-measuring cylinders or similar small cylindrical work, have contact faces of $\frac{1}{8}$ in. diameter; others with contact faces of $\frac{1}{4}$ in. diameter are available for larger work.

POSSIBLE ERRORS

An instrument of this type is intended to be used as a comparator, the size of the work being determined by comparison with a suitable standard of similar form. The use of the wedge reduces the range of travel of the lower measuring anvil to 0·1 in., which sets a maximum limit for the difference in diameter of work and standard. It is not, however, desirable to use this maximum difference, when it can be avoided, because error may be introduced on account of a progressive error of the micrometer screw, or because the angle of the wedge may be incorrect. The maximum progressive error of the screw allowed by the British Standard is 0·0001 in. over the 1 in. travel; if present, this would result in an error of 10μ in. in the corresponding 0·1 in. movement made by the lower measuring anvil.

An error of 2 seconds in the angle of the wedge would also introduce an error of 10μ in. in the displacement of the anvil. The combined error due to both sources can, of course, be determined by calibrating the instrument over the 1 in. travel of the micrometer spindle by means of slip gauges. The more troublesome periodic error of the micrometer screw is rendered negligible by the use of the wedge: the British Standard allows a maximum periodic error of 0·000,02 in. and this is reduced by a factor of ten.

At the Laboratory, the comparator has been used with standards differing in size from the work by no more than about 0·01 in. and an accuracy within $\pm$ 0·000,01 in. is readily attainable under these conditions.

Acknowledgments.—The comparator was constructed by Mr. G. P. Goymour and much assistance was given by Mrs. J. G. Wood during its development.

The work described has been carried out as part of the research programme of the National Physical Laboratory, and this article is published by permission of the Director of the Laboratory.

REFERENCES

[1] *Gauging and Measuring Screw Threads* (Notes on Applied Science No. 1). H.M.S.O., page 11, 1955.
[2] F. H. Rolt, "The Development of Engineering Metrology," The Sir Alfred Herbert Paper, 1952, *Proc. Inst. Prod. Engrs.*, page 6.
[3] *Gauging and Measuring Screw Threads*, page 15
[4] "The National Physical Laboratory," ENGINEERING, vol. 110, page 19, 1920.
[5] *Gauging and Measuring Screw Threads*, page 23.
[6] F. H. Rolt, and A. Turner. "A Machine for Measuring Plug Screw Gauges in Quantities," *Machinery* (London), vol. 52, page 701, 1938.

HYDRAULIC TURNTABLE LADDER FOR FIRE-FIGHTING

Shown in the accompanying illustration is a new hydraulic turntable ladder for fire-fighting duties introduced recently by Merryweather and Sons, Limited, Greenwich High-road, London, S.E.10. The ladder, which is mounted on a specially adapted Merryweather-A.E.C. chassis, is of welded steel construction, in four sections, capable of extension to 100 ft. Elevation, extension, and slewing are all hydraulically actuated, with handgear for emergency use, hydraulic power being supplied by a pump driven by the road engine.

Elevation is carried out by twin hydraulic cylinders, each of which incorporates a built-in control valve and a self-actuating mechanical lock which sustains the rams independently of hydraulic conditions. An hydraulic motor drives the extension mechanism, and when the ladders are being housed this same motor acts as an oil brake. Slewing is by means of a reversible hydraulic motor driving a fully enclosed worm reduction box.

The plumbing installation, which ensures that the ladder axis remains in the vertical plane is fully automatic in action and is also hydraulically actuated. At angles of elevation below 30 deg. the ladder is guided back to the central position on the swinging frame ready for lowering on to the headrest.

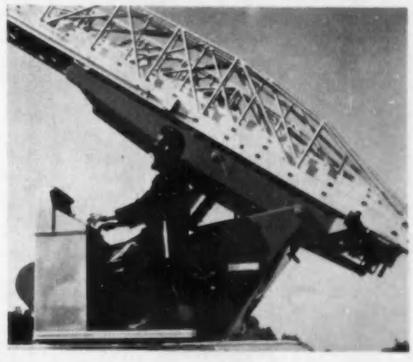
A console-type desk unit is mounted on the turntable platform itself and revolves with the ladder. It faces forwards giving the operator a clear view of the head of the ladder.

The speed of operation of each of the three movements is determined by the position of the relevant control lever, and is infinitely variable from zero to full speed on each movement independently. Hence it is possible to elevate at full speed whilst training slowly, or to extend slowly whilst training at faster speed, etc.

A pedal below the console sets the whole mechanism in a state of readiness and acts as a "dead man's" control. The mechanism is fully locked, and operation of the individual controls has no effect until this pedal is actuated. In addition the individual controls are spring loaded to the neutral position.

The manufacturers claim that the ladder is extremely simple to operate and smooth running; various protective features safeguard it fully under the most difficult operational conditions. Particular care has been devoted to reducing maintenance by minimising the number of parts subject to wear—there are no clutches and little gearing—and by providing ready access and replacement on the unit principle.

Orders for the new Merryweather turntable ladder have already been received from the Fire Brigade Authorities of Bournemouth, Burnley, Liverpool, Manchester, South Eastern Area (Scotland), Southport and York.



Independent, infinitely-variable speed adjustment is provided on all three motions of the Merryweather hydraulic turntable ladder.

TOWER BOX PURIFIERS FOR TOWN GAS

Work is to commence at the end of the present year on a tower box purifier for town gas to be installed at the Worcester Gas Works of the West Midlands Gas Board. The plant which is to cost £135,000 is to be erected by Henry Balfour and Company Limited, Durie Foundry, Leven, Fife. The tower box design consists of a large welded steel container sub-divided into five towers. In each tower there are six trays containing oxide for the removal of sulphur impurities from the incoming gas, which enters each tower through large connecting mains. The spent oxide is changed by a mechanical device which tips it from the trays, subsequently re-charging them with fresh oxide. Initially the plant will have a total oxide capacity of 28,400 cub. ft., and the gas throughput will be 4,000,000 cub. ft. a day. Eventually it is hoped to double this throughput by the addition of further oxide-holding trays. The present installation is scheduled to be completed by the end of 1958. Henry Balfour have already installed tower box purifiers at the Southall, Bow Common, Rotherham and Beckton Gas Works.

Being flexible, these heating mats can be fitted round most surfaces. Temperatures up to 1,000 deg. C. can be attained.

FLEXIBLE FURNACES

An electric heater which has been designed to fit around any curved surface has now been put on the market by Electrothermal Engineering Limited, 270 Neville-road, London, E.7. It basically consists of resistance wires threaded through interlocking temperature-resistant ceramic blocks, to form a mat of the type shown in the illustration. It has a design surface loading of up to 50 watts per sq. in., and at this rating temperatures up to 1,000 deg. C. are obtainable.

Each of the ceramic blocks measures approximately $\frac{1}{16}$ in. thick by $\frac{3}{4}$ in. by $\frac{3}{8}$ in., and functions independently of its adjacent members, but at the same time is attached to them. This arrangement allows the heaters to be applied to parts having as small a diameter as $\frac{1}{2}$ in. At the same time, curvatures with a minimum radius of 24 in. can be accommodated in a direction at right angles to that of maximum flexibility. A certain amount of dual curvature can also be obtained.

Heaters can be supplied up to 48 in. square and, where the working surface is greater than this, two or more can be linked together. Equally they can be supplied in a variety of other shapes. The smallest of the standard types measures 3 in. by 12 in., and has a design rating of 1,250 watts at 25 volts. In contrast, the 24 in. by 36 in. size has a rating of 30,000 watts at 100 volts. Typical applications are pre-heating or stress-relieving in welding, annealing, shell moulding or the heating of pipe lines.

JET TOWN-GAS BURNER

FOR SELECTIVE LOCAL HIGH-INTENSITY HEATING

Recent research in the gas industry has resulted in the development of high-pressure jet burners using town gas for selective local heating, and these burners are applicable in many processes, where high-intensity heating is required.

In the normal Bunsen type of burner, the rate of heat release is some 0·5 to 1·0 million B.Th.U. per cubic foot of flame volume. This can be varied by modifications to the burner design, and the provision of pre-mix plant or air-blast type of burners enables the rate of heat release to be increased to some 2 to 3 million B.Th.U. per cub. ft. of flame volume. Recent research, however, has made it possible to increase the rate of heat release within refractory tunnels up to some 250 million B.Th.U. and it is this work, conducted in the research and development centre of the North Eastern Gas Board, Leeds, which has resulted in the production of the above-mentioned high-pressure jet burners. In this type of burner, combustion is completed very rapidly in a chamber or refractory tunnel and the resultant gases, at temperatures of 1,750 deg. C., are discharged from a narrow opening at the tunnel mouth, at supersonic velocities. The combination of high temperature and high velocity gives these burners their very high heating potentials.

With these burners not only are high temperatures attained, but heating times have been greatly reduced, as compared with older methods, and the need for surrounding the material to be heated with an insulating refractory chamber, to prevent heat losses, has been much reduced. Thus, the development of " furnace-less " heating has emerged.

In industry, for the heat treatment of metals, it is possible now, by the use of correctly-placed tunnel burners, to heat only a small portion of a complex structure without materially raising the temperature of the bulk of the piece, and a striking example of this is the preheating of valve seats prior to metal deposition. By the use of the jet burners shown in Figs. 1 and 2, the internal seats of steam and other engine valves weighing up to 2¼ tons can be raised to a temperature of 750 deg. C., in some 12 minutes, although the seat is situated within a highly-conductive structure. From this it will be realised that large production economies are likely when this unconventional method of heating is adopted.

A further illustration of the remarkable achievements of jet-burner heating was demonstrated recently in the steel pipe and tube works of Clayton, Son and Company, Limited, Pepper Road Works, Hunslet, Leeds, 10. The new burners have been applied to the lap welding process for the production of high-quality large-diameter steel tubing for the water, gas, oil and sewage engineering industries.

From the year 1906, when the founder of the firm, Mr. Lawrence Clayton, devised a machine for welding the longitudinal seams of steel pipes by what is now known in the trade as the " water-gas roller welding process " this method has continued in use in spite of the development of automatic electric-arc welding; it is stated that the latter process is not suitable for universal application. The introduction of the high-intensity gas burner has permitted town gas to be used and has provided an alternative means of carrying out the roller welding process more efficiently and economically than heretofore.

Steel plate is rolled to form a ½ in. lap joint, which joint is then heated to some 1,500 deg. C. and rolled under a pressure of 12·5 tons. Under the influence of this temperature and pressure, a weld of high quality is produced. Large jet burners had to be designed for this work and these are illustrated in Figs. 3 and 4 and demonstrated in action in Fig. 5. In these burners up to 4,000 cub. ft. of coal gas is burned per hour in the limited space of 0·026 cub. ft.

Results obtained on a tube having a length of 22·8 ft., a diameter of 27 in. and a plate thickness of $\frac{3}{16}$ in. indicate the advantages gained by the substitution of coal gas for water gas for this particular process. The total time to weld the pipe with coal gas was 99·5 minutes, as compared with 139 minutes with water gas. The welding time was 75·5 minutes, the length of weld finished per hour 14·3 ft., and the time taken to reach 1,500 deg. C. on the first heat, 2½ minutes by the new method, as compared with 119 minutes, 10·2 ft. and 4½ minutes by the old method. These figures illustrate that the use of coal gas in the new jet burners has effected a reduction in fuel cost of 50 per cent. and an increase in production rate of 26·5 per cent.

There appears to be no reason why similar results should not be obtained in many applications of these burners where they are designed to replace the more traditional systems, and also why their use should not be extended to other process work for which fuels other than coal gas are at present used. It should be emphasised, however, that in jet burners where the maximum point of heat release is only some 1 in. from the mouth of the burner these must be " tailor-made " for the task in hand.

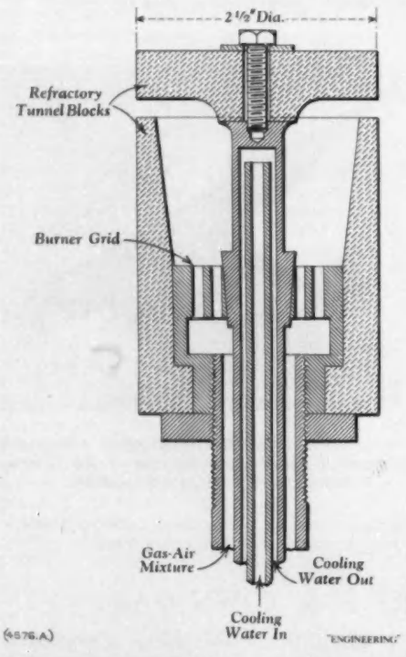


Fig. 1 Longitudinal cross-section of an internal valve-heating burner of 2½ in. external diameter.

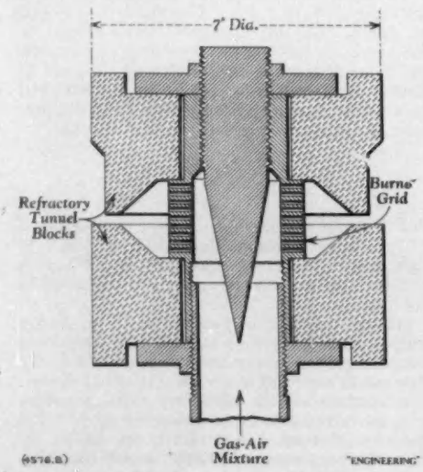


Fig. 2 Another type of internal valve-heating burner having an external diameter of 7 in.

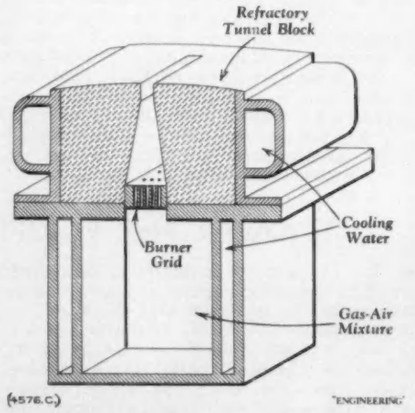


Fig. 3 Internal welding burner for forming the lap joint of a steel plate rolled to produce a tube by the gas roller welding process.

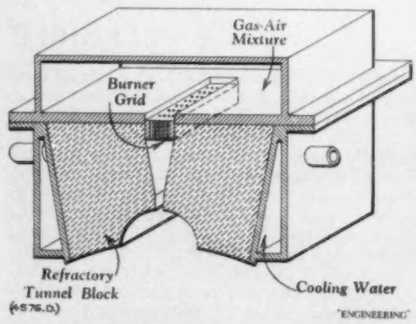


Fig. 4 External plate-welding burner for use in the gas roller welding process.

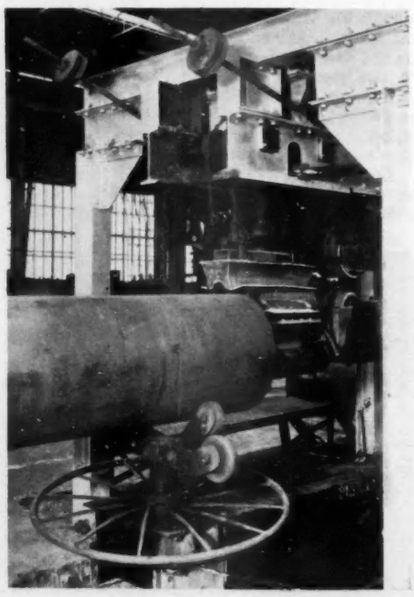


Fig. 5 Commencement of gas roller welding process for making steel tube from plate at the works of Clayton Son and Company, Limited.

WIRE TELESCOPE FOR RADIO ASTRONOMY

Aperture Synthesis Technique Simulates Aerial 200,000 sq. ft. in Area

When Sir Edward Appleton opened the the new Mullard Radio Astronomy Observatory at Cambridge he remarked "I'm going to claim that Mr. Ryle's work is entirely in the famous tradition of the Cavendish Laboratory in that he believes in concentrating as much thinking into as little apparatus as possible." The aerials at the observatory bear this claim out. Each of the two main aerials is made to do the work of an equivalent system many times its own size.

In extending their facilities, the Cambridge radio astronomers, led by Mr. M. Ryle, F.R.S., decided to build a number of specialised instruments rather than a single general-purpose one like that at Jodrell Bank. Consequently their new aerials—two systems are almost completed—are designed to tackle specific problems. One of the new systems will be used to study radio stars. The other will be used to study the background radio noise coming from our own Galaxy.

An aerial for studying faint radio signals from remote sources—the signals from radio stars are pre-eminent in this category—must meet two main requirements. It must have a large collecting area so that it can pick up as much energy as possible; and it must have a high resolving power so that it does not pick up interfering signals. Rather than produce an aerial that covered an extremely large area, Mr. Ryle has used a technique whereby two aerials of practicable size are made to simulate an aerial that would otherwise be of impracticably large area. The technique is called "aperture synthesis."

The aperture synthesis system used at the Mullard Observatory consists of a fixed aerial and a moving aerial. The fixed aerial can be considered as occupying one side of the imaginary square that is synthesised, while the moving aerial travels at right angles to it.

At each position of the moving aerial, readings are taken of the power entering the two aerials. Also at each position the signals are mixed and further readings are taken—these provide information concerning the relative phase of the signals as they enter the two aerials. The collected readings give the basis for calculation of the results that would have been obtained with the synthesised aerial.

One complete set of readings will take several months. Over such a period the characteristics of the atmosphere may change sporadically and the amount of interference vary. To decide the validity of each reading a monitoring system will be operated continuously. It is possible that an average of one in three readings may have to be rejected.

To achieve the necessary resolution, the radio star aerial system is operated as an interferometer. In a radio interferometer the aerials are connected so that sensitivity to incoming radio waves varies rapidly with the angle of arrival of the waves. The pattern of sensitivity depends on the spacing of the aerials—measured in wavelengths—and the manner in which they are electrically connected. A small radio source that moves straight across the field of an interferometer will occupy, successively, a series of directions of maximum and minimum aerial sensitivity. Thus the signal from a constant radio source will fluctuate regularly in intensity with the passage of the source across the field of the aerial.

If the radio source is large it will overlap several positions of maximum and minimum intensity. In this case the received signal will not vary in intensity. Adjustment of the aerial pattern until a given source ceases to produce a fluctuating signal, provides a method of measuring the diameter of the source.

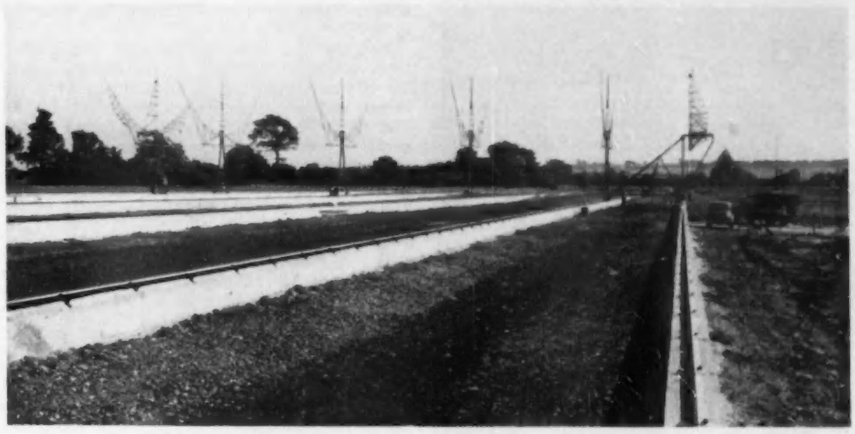


Fig. 1 The new aerial at Cambridge for studying radio stars has a moving section that requires accurate positioning. The rail track on which it moves is laid to an accuracy of $\frac{1}{16}$ in. in line and level.

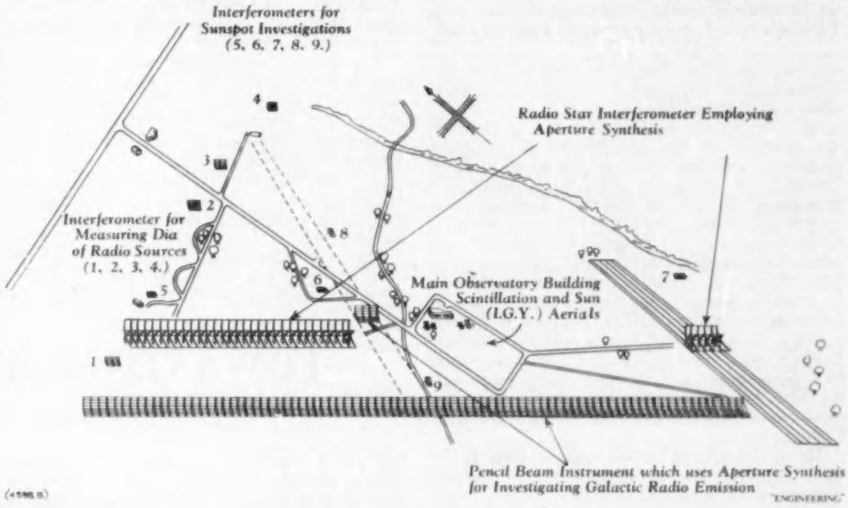

Interferometers for Sunspot Investigations (5, 6, 7, 8, 9.)
Radio Star Interferometer Employing Aperture Synthesis
Interferometer for Measuring Dia of Radio Sources (1, 2, 3, 4.)
Main Observatory Building Scintillation and Sun (I.G.Y.) Aerials
Pencil Beam Instrument which uses Aperture Synthesis for Investigating Galactic Radio Emission
"ENGINEERING"

Fig. 2 The general layout of the Mullard Radio Observatory at Cambridge shows the layout of the two new radio telescopes. Each employs the technique of aperture synthesis.

The aperture synthesis technique, since it requires a fixed and moving aerial, lends itself readily to interferometric methods and allows a high degree of resolution to be obtained. However, additional readings have to be taken and the synthesis of the calculated data calls for complex calculation. Therefore, the Mullard Observatory has sought the co-operation of the University Mathematical Laboratory, and methods are being developed to enable the use of the EDSAC computer.

The main constructional difference between the galactic background aerial, which is not an interferometer, and the radio star aerial, which is, lies in the relative positions of the fixed and moving aerials. Both arrangements are shown in the general plan of the site given in Fig. 2. The galactic background aerial is synthesised as a cross—the path of the moving aerial meeting the centre of the fixed aerial. In the radio star aerial, on the other hand, the path of the moving element passes at some distance to the east of the end of the fixed aerial.

The new observatory is located at Lord's Bridge, some five miles south-west of Cambridge. The site is a triangular piece of land that covers an area of about 180 acres. There is sufficient space for an aerial to extend 3,500 ft. east and 2,000 ft. south. A benefaction by Mullard Limited, Torrington-place, London, W.C.2, amounting to £100,000, provided over a period of 10 years, together with a grant from the Department of Scientific and Industrial Research, made the extension possible. The observatory remains part of the Cavendish Laboratory.

Earlier work at Cambridge led to the detection of 2,000 radio stars. Only about ten of these can be identified with visible objects. The Cambridge workers consider that measurements they have made show that at very great distances the radio stars are closer together. If their conclusion is correct it would seem to favour a theory in which the universe is supposed to be expanding from an initial highly condensed state, and to conflict with one in which there was supposed to be continuous creation of matter. Radio astronomers in Australia have criticised the Cambridge results. With a different kind of radio telescope they have been unable to repeat the Cambridge observations.

Other work at the Cambridge observatory has been a detailed study of the radio waves from the sun and from the Crab nebula. Measurements made on the latter, during the course of

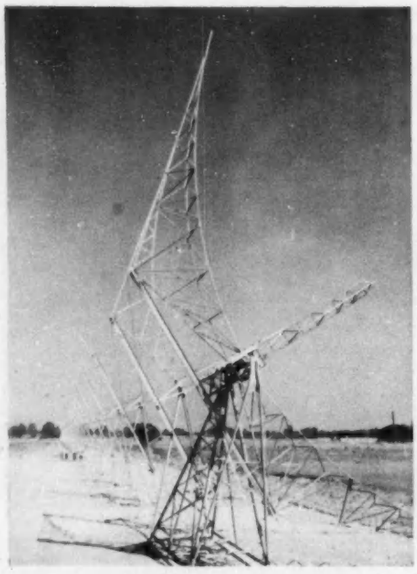


Fig. 3 The construction of the steelwork making up the parabolic frames is shown partly completed. Later, the towers were mounted on a concrete beam.

its occultation by the moon, suggest that the atmosphere of the moon is 2×10^{-12} less dense than that of the earth.

At a dinner given by the University to mark the opening of the observatory Sir Edward Appleton proposed a vote of thanks to Mullard Limited. In his reply, Mr. S. S. Eriks, the managing director of Mullard Limited, had something to say about the practical value of radio astronomy: "People sometimes ask me what practical outcome I expect for my company from this radio astronomy venture and I have to confess that I just don't know, which is probably a very good thing because otherwise I might be accused of having ulterior motives. I don't suppose Lord Rutherford had much idea of nuclear reactors when many years ago he and his colleagues were unravelling the mysteries of atomic structure in the Cavendish Laboratory."

The aerial system for the study of fixed radio stars works on a wavelength of 1·7 metres. Various considerations influenced this choice. A shorter wavelength would call for more rigorous mechanical accuracy (already of a high order), the signals received would be fainter, and electronic equipment less sensitive. A longer wavelength would require a larger aerial if the resolution was not to be impaired. Also the wavelength had to be well removed from that of any local transmitter—television and mobile radio systems being stentorous occupants of this part of the radio spectrum.

The layout of the radio star aerial can be seen in Fig. 2. The axes of both fixed and moving aerials lie in an east-west direction. The former is 1,450 ft. long, the latter 190 ft. Both aerials consist of cylindrical parabolic reflectors that concentrate incoming radio waves on to dipoles at their foci. The reflector is made by stretching galvanised iron wires across tubular steel frames that can rotate about the east-west axis. The construction of the frames can be seen in Fig. 3. The surface of the reflector contains 320 wires spaced $\frac{1}{32}$th of a wavelength apart.

The envelope of the aerial's intensity pattern will have a width at the half-power point of about 25 × 35 min. of arc. This will contain an interference pattern in right ascension that has a lobe separation of about 8 min. of arc. The equivalent collecting area of the instrument will approximate to 190,000 sq. ft.

Each aerial is made up in sections. The frames, which are shown only partly completed in Fig. 3, are mounted on a low concrete beam. There are 33 towers in the fixed aerial. A $\frac{1}{4}$ h.p. electric motor on each tower rotates the frame 60 deg. either side of vertical by means of a chain drive. A cam, operated each motor-revolution, maintains the section alignment to within 2 deg. The moving aerial has a similar system.

Perhaps the most noteworthy engineering achievement is the track for the moving aerial. Six rail tracks are laid to an accuracy of $\frac{1}{16}$ in. in line and level over a total length of 1,000 ft. The track does not follow the curvature of the earth. In fact the rails describe a horizontal plane tangential to the earth's surface at a point of reference near the centre of the rail system. The track is laid on reinforced concrete beams that are supported by short-bored piles 11 ft. long. The piles stand on blue clay.

The foundations for the track were laid by John Mowlem and Company, Limited, Millbank, London, S.W.1. All the steel-work in the aerial system was done by D. Mackay Limited, Cambridge.

The moving aerial will move 10 ft. each day when observations are being made. Electric motors drive it along the rails. To take up the tension in the aerial, which is subject to varying weather conditions, there is a system of suspended weights at each of the ends of the two parts. On the moving aerial, to withstand larger thrusts —such as might be expected with the maximum snow load—two of the rail tracks are canted. These tracks, that can be seen in Fig. 1 as the tracks next to the outside tracks, can take up to 15 tons horizontal thrust.

The galactic background noise aerial is of simpler construction. It is a pencil beam instrument and is designed to work at a wavelength of 7·9 metres. Previous observations at shorter wavelengths, although of high resolution, were limited by lack of sensitivity. Observations at longer wavelengths have revealed many unexpected features, so that it was clearly worthwhile to produce a high-resolution instrument for such wavelengths.

The main fixed aerial is 3,200 ft. long. The moving aerial can be moved over a path of 1,700 ft. Each aerial is in the form of a corner reflector that has an aperture of 40 ft. Part of the fixed aerial is shown in Fig. 4. Both aerials are made up in sections and Dexion used as the constructional material throughout. The moving aerial has four sections each of which weighs about 1 cwt. When the aerial needs moving each section is carried independently to its new position.

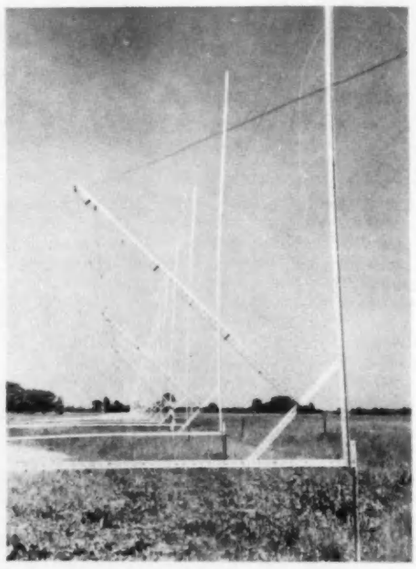


Fig. 4 The galactic background-noise aerial has a fixed section 3,200 ft. long. The equivalent collecting area is about 200,000 sq. ft.

The aerial, built by the staff of the observatory, has a sensitivity pattern that is about 1 × 1 deg. to the half power point. The equivalent collecting area is about 200,000 sq. ft.

TOWARDS A UNITED EUROPE

A Five-Year Experiment in Coal and Steel

In the tense and dramatic moment of overhanging defeat, Winston Churchill's offer to France of common citizenship in 1939 was the spectacular expression of faith in an idea, by the great political visionary of our time. He believed that complete unity, economic and political, was the best means of growing strong and therefore of fighting on. Thus the seed was sown of the concept of European unity. It was the realisation, shared by few of his contemporaries, that the chronic conflict between France and Germany was a source of weakness and a bar to European development which he passed on to others. A united Europe with Britain and Germany as balancing wings, could grow and outstrip the economic growth of the West and the East. Churchill's seed is now a healthy young sapling. Others have taken over his lead and have progressed so far in a few years that there is a real prospect of a United States of Europe within one or two decades. The best reason for going ahead with the integration of the coal and steel industries, with Euratom and with the Common Market is that they are politically inevitable. It is useful to realise this when considering any of the problems such a unifying process brings about. The political inevitability of a United Europe, and this means a Europe integrated industrially and economically, before it is so politically, cannot be resisted for the alternative is decline, fall and vassalage.

Two men, both great Europeans, have taken over the lead from Sir Winston Churchill. One, a Belgian, Paul-Henri Spaak, is inbred with the deep belief that militant Christianity is both the driving spirit and the mortar needed for unity. The other, a Frenchman, Jean Monnet, has the imagination, vision and planning ability to instigate practical measures and to push them through until they are adopted. He is one of the principal architects of the Schuman Plan and the first president of the Coal and Steel Community. The Action Committee for a United States of Europe, which he leads, is now campaigning for the ratification by the six member countries of Euratom and the European Economic Community (the Common Market). Such measures are inevitably painful to some, for they involve changes in the location of industry and can vitally affect firms and individuals. They will be fiercely resisted, for each of us—and collectively through our elected representatives and governments—is loath to surrender any of what we view as our rights to determine our own destinies. Yet the concept of a United States of Europe is established and the means developed to bring it about. We believe it to be politically inevitable, and certainly the lesser of two evils if it is considered as one. Adaptation to the changes it involves is therefore necessary and urgent. The appointment by the directors of I.C.I. of a colleague whose sole task will be to consider the implications of such developments for their company and to advise them is the clearest indication so far of British industry's awareness of the inevitability, and the magnitude, of the change.

COMMUNITY FOR COAL AND STEEL

The setting up of an organisation to integrate the coal and steel capacity of Western Europe

in August, 1952, was the first step taken by Western Europe towards economic integration. It is the purpose of this article to review what has been done in these five years, partly because of our readers' vital interests in European steel, partly to find in the Community's experience some guide as to the impact on industry of the next moves towards integration. To quote Sir Cecil Weir, chairman of British Tabulating Machines Limited, who was head of the United Kingdom delegation to the High Authority from 1952 to 1955, the Community is " in itself an example of successful integration in a restricted sphere " but has " an equal, perhaps a greater, importance as a demonstration of what integration is, and how it might be applied to wider fields." The adoption of two of the Community's organisations—the Common Assembly and the Court of Justice—to serve in the case of Euratom and of the Economic Community is a clear indication that the framework of the Coal and Steel Community has proved itself to be practical and effective.

The organisation of the Community for Coal and Steel is run by a nine-man executive, with a permanent staff of about 600 located mainly in the headquarters in Luxembourg city. The executive is a powerful body, whose decisions are binding on the governments of the member states and on the coal and steel industries themselves in each country. The essential difference between the High Authority and an international organisation is that its members are not in any sense representatives of their countries. A visit to Luxembourg quickly establishes this fact: the High Authority and its staff are members of the Community for Coal and Steel, not Frenchmen or Germans or Englishmen. The spirit of loyalty to the organisation and the belief in its autonomous impartiality surprises many.

The organisation of the Community and the relationship between its various bodies is shown in the accompanying chart. Essentially, the High Authority is a policy body, which takes decisions with the assistance of a consultation committee of 51 members (divided equally between employers, workers and consumers). Its functions, which are described later, are broadly similar to those of the Steel Board in this country, though the degree of responsibility for the industry's development is probably greater and the dependence on the governmental directives (in this case, the " government " is the Common Assembly) rather less.

The High Authority's powers—for example to levy and collect its own tax on coal and steel production (up to 1 per cent. of turnover, currently 0·35 per cent.) or to look into any one company's affairs, or to fine firms violating Community rules—are clearly defined and set down. It is responsible for its policy not to the national states but to the Common Assembly, which is a parliamentary body of 78, elected by and from the legislatures of member countries. The High Authority reports annually to the Common Assembly, which can oust it by a vote of censure carried by a two-thirds majority. The Court of Justice is the chief safeguard against abuse of authority: it is a tribunal of seven judges who have the sole power to decide whether decisions of the High Authority should be upheld or quashed. It is to the Court that the member states' governments, the coal and steel industries and the Council of Ministers (who meet to harmonise national policies with those of the Community) can appeal when they disagree with the High Authority. But the High Authority has power to compel the national governments to enforce its decisions, and to enforce them directly against enterprises. That such powers have rarely been used is not a sign of weakness or inactivity but of the smoothness with which the High Authority's functions have been exercised so far.

THE HIGH AUTHORITY'S FUNCTIONS

Basically, the task of the High Authority is to facilitate and stimulate the growth of the coal and steel industries of western Europe. For this reason, as Jean Monnet so clearly put it, " our Community is not closed upon itself, but on the contrary open to all who wish to join." The main directions in which the High Authority has acted so far—discussed in some detail under each heading—are first, the removal of obstacles to trade within the Community, including all tariffs and quotas and all frontier restrictions on transit goods. Second, and perhaps most important " structurally," to guide and to encourage the industries to re-organise themselves in a more efficient manner discounting all considerations of nationalities and to expand in directions most likely to offer good long-term prospects either of greater sales, or of economy of materials, saving of costs, etc. The third function, which is complementary to the second, is to stimulate research in all important fields, i.e., products, processes and plant. The fourth is concerned with the training, welfare and health of the employees. What has been achieved is briefly reviewed under each heading. But apart from achievements of a measurable kind, there is something far less tangible and perhaps even more valuable. It is the habit that the coal and steel industries of western Europe have developed, of working together, tackling their problems on the basis of a common policy, pooling their resources and their discoveries. It is the resultant attitude of mind which is so important in considering the future of other concerted efforts by the nations of Europe.

The influence of the High Authority has grown in step with the achievements of the industries concerned. When it took over, industry in western Europe was stagnating; since then output of steel has risen by 36 per cent., between 1952 and 1956. In its fifth annual general report the High Authority does not seek to claim the whole credit for this advance: industrial production in Europe has been expanding as never before. It does claim, however, that expansion in steel production has been greatly assisted by " a more regular flow of coal supplies, by more active and stable trade in iron ore between the member countries, by the reduction in international freight charges in conformity with the Treaty, and by the possibility of a co-ordinated policy regarding scrap imports."

Crude steel production reached 56·8 million metric tons in 1956, 4·2 million tons more than in 1955. There has been a 50 per cent. expansion in five years, averaging 7½ per cent. a year. This rate of increase is expected to drop back to 5 per cent. per annum over the next four years and production in 1960 is forecast at 73 million tons, rising to 78½ million tons in 1965 and to 105 million tons in 1975. The latter figure is taken as indicative of the general trend; the High Authority is using it only as a basis to estimate the Community's coke requirements.

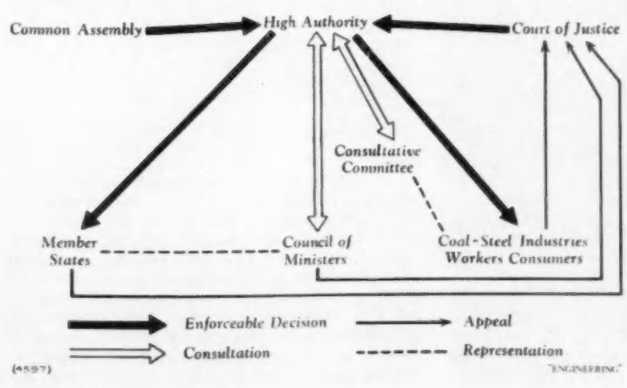
These are very high figures. They are based on surveys carried out by the High Authority and have been built up with the assistance of steel using industries. The Community's market research is on a large scale and very thorough, and there is a great deal of confidence that the " general objectives " the High Authority sets for coal and steel are realistic and more likely to prove right than wrong. So far the rate of expansion has been consistently higher than forecast. Yet the Community's share in world production, which had been falling steadily from 1929 to 1951, rose by over 2 per cent., to over one-fifth of the total in 1956.

COMMON MARKET

One of the first jobs of the High Authority was to abolish obstacles to trade within the Community. This meant not only tariffs and quotas, but currency restrictions, dual pricing, subsidies, compensation schemes, equalisation schemes and the host of measures devised by the governments or industries of the member countries to provide protection or competitive advantages. Another major task was the abolition of discriminatory transport rates and the abolition of frontier charges.

The general effect of these measures was to promote trade within the community and to increase competition between firms. This did not take place without hurting some firms, both in the steel industry and outside it. For example, the Italian government were requested to take action on various duties and tax exemptions enjoyed by Italian shipbuilders; the French government were asked to revoke certain special terms and tariff concessions allowed to manufacturers of agricultural machinery in their purchases of steel. Some of the steel works were unable to compete and had to close down. Others, relatively strong, prospered and increased considerably in size. Radical changes took place in the areas supplied by various firms. For example, the quickly growing Italian steel industry is to supply the South of France and the steel works of eastern France are selling their products across the frontier in Germany. Trade in iron and steel products between Community countries increased from 2·1 million metric tons in 1952 to 5·7 million tons in 1955 and although there was a drop last year, the level is still 2½ times what it was when the High Authority took over.

On prices, the High Authority restricts its activities to preventing the imposition of taxes or subsidies which would limit competition. Its treaty contains the provision that it will control prices and fix quotas solely in the event of a slump. Otherwise it can only give guidance on price levels and ensure that there is fair play and honesty by publishing all prices and commenting on price movements. Manufacturers have proved remarkably cautious in determining their price policies. The fear that any departure from normal practice, for example, by granting preferential prices for any reason, would precipitate an upward or downward spiral has acted as a strong deterrent to fluctuations. The chief offenders have been the national governments who attempt to influence price levels to suit their particular economic situation. Where such interventions threaten to prejudice the realisation of the High Authority's objectives, strong protests are made, usually with success. Price studies, and the discussion of their influence on the industry's prospects, have proved a useful method of influencing price movements in line with the industry's long-term interests, or at any rate with the High Authority's interpretation of those interests. The fact is that, with the exception of sheet steel where U.K. prices have risen less than any others, the Community's prices have risen less than either American or British. The index of home prices of merchant steels in the Community stood at 108 (May, 1953: 100) in February, 1957, compared to 118 in the case of the U.K. and 128 in that of the U.S. There were of course differences within the Community—firms in France and Germany



increased their prices less than their competitors in the other four countries. By and large, however, the High Authority would appear to have been successful in keeping down prices by freeing trade and promoting competition.

STEEL MAKERS ADAPT THEMSELVES

The sudden introduction of free trade, even in a small and compact area like that made of south-western Germany, Belgium, Luxembourg and north-eastern France, was bound to have profound effects on the structure of the industry. This area, which produces 90 per cent. of the coal and 70 per cent. of the steel of the Community, is a mighty assemblage of capacity which favours concentration of manufacturing units. A report on mergers between steel firms, over all of which the High Authority has the power of veto (not yet exercised) was presented last May to the Community's Common Assembly. Thirty-one cases of concentration arose since 1952, 18 in Germany, 8 in France, 5 in Luxembourg and 3 in Belgium. All but three concerned steel firms and 20 of these were concentrations of a vertical type, i.e., between steel firms and their suppliers of raw materials between steel firms and their customers. This trend is likely to continue, and it seems likely that the size of firms will increase until they become related to the size of the market. Much will depend on the degree of technical and financial concentration which is considered desirable. Studies of production techniques suggest that the optimum size of a works is far smaller than is justified on marketing, technical and financial grounds.

PROBLEMS OF ORE AND SCRAP

The tendency of steel firms to acquire coal and iron-ore mines illustrates the general concern that exists about raw-material supplies. The signs are that, although the shortage is now growing, the industry's apprehension has become less since the High Authority has concerned itself with their availability. It is nonetheless clear that additional production will become difficult unless higher imports of raw materials can be secured. Iron-ore imports, which amounted to 29 per cent. of the total in 1956, will amount to 39 per cent. of a larger total in 1960. Coal imports will likewise have to be increased, for although there are enough supplies of coking coal it cannot all be reserved for steel making. The acute shortage of scrap during the past three years has made the expansion of output even more difficult.

The work of the High Authority in this field is of considerable interest. The general policy is to reduce the imports of ore and to minimise consumption through the installation of more modern blast furnaces operating under higher pressures, of more converters using oxygen to increase the efficiency of the process. It is also the policy of the High Authority to encourage the use of sintering furnaces. Such policies, in so far as they affect the investment of firms within the Community, are pursued through the exercise of the right to scrutinise all major investment projects. The High Authority has the power to assist in the financing of developments it wishes to promote, usually by lending money it has itself borrowed at rates considerably below those prevailing on the Community's capital markets.

The High Authority is sufficiently concerned about ore supplies, and particularly about supplies of good-quality ores, that it does not rule out the possibility of investing in distant ore mines, as the United States companies have done. But the shipping problems involved in raising ore imports from 18 million tons in 1951 to 50 million tons in 1965, and the problems of the capacity of inland waterways and land transport are considerable. According to a senior official of the High Authority, "no one has yet had the courage to calculate what it all means in terms of hundreds of millions of dollars." The bulk of the investment required will have to come from the steel industry itself. The re-location of many of the steel works to the sea shore is an almost inevitable development.

(*To be continued*)

ATOMIC REVIEW

L'Energie Atomique

FRANCE leads continental Europe in the production of electricity from nuclear energy. Furthermore, she will soon be an important producer of plutonium. Opportunity is taken in this article to continue the survey, started early this year, of national nuclear power programmes, by describing that of France. An important omission is the description of the large reactors at Marcoule. They will be considered in greater detail at a later date.

The Commissariat à l'Énergie Atomique came into being in 1945. It is responsible for the scientific, industrial and military development of nuclear energy. It is a public body that has financial and administrative autonomy. The administration is carried out by the Comité de l'Énergie Atomique which is assisted by the Conseil Scientifique, the Comité des Mines, and the Comité de l'Équipment Industriel, by representatives of the public services, universities, and industry.

In 1945 prospecting for uranium ore started. The first five-year plan for nuclear development began in 1952. The first big increase in expenditure came in 1955 when 37,000 million francs were made available as compared with 7,000 million in the previous year. The original five-year plan envisaged an output of 50 kg. of plutonium a year. In 1955 the proposed figure was increased to 100 kg. per annum.

Originally, the French decided that plutonium would be the most economical fissile material for them to produce. But they made it clear that the construction of a gaseous diffusion plant for the separation of U_{235} was not out of the question. The second five-year plan, placed before the French National Assembly last April, does envisage the construction of a gaseous diffusion plant. Having bought 40 kg. of U_{235} from the United States last year, the French have been able to assess its possibilities. But rather than be reliant on supply by a foreign country they are considering separating it themselves, even though the cost to do so may be three times that of buying it from the United States.

France is the second country to ratify the Euratom agreement. Itis likely that if Euratom were to decide to build an isotope separation plant France would abandon her own project or restrict it to a much smaller scale. However, in *Target for Euratom* a very cautious approach is made to the suggestion of isotope separation and it seems unlikely that plant will be constructed except by the efforts of individual countries.

France is also a prominent member of CERN. Her contribution during 1956 was 23·84 per cent.—equal to that of the United Kingdom and not exceeded by any other member. The next largest contributor was the German Federal Republic, with 17·7 per cent.

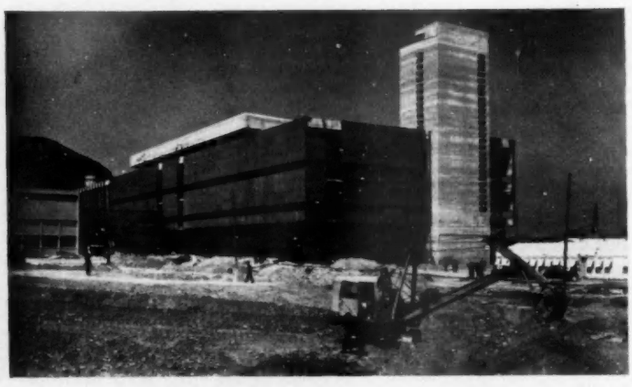


Fig. 1 The staff of the fuel processing plant at Marcoule control all operations from the two outside galleries.

About 500,000 million francs are to be spent during the next five-year plan. This is an overall figure that includes expenditure in Euratom and by public utilities. The direct expenditure by the C.É.A. will be 384,000 million francs. Quite a substantial increase has therefore accrued: the total expenditure from 1945 to 1957 amounted to 150,000 million francs. The new plan provides for about 800 MW of nuclear power. However, it has been suggested that this is a minimum figure and that it is likely that it will actually increase by a factor of three.

Like most other countries France has a shortage of skilled engineers. It is thought that 5,000 engineers will be required in the nuclear field in 1957 and that the figure will increase annually at a rate of 25 per cent. Close attention is being given to replanning university courses in order to meet the new demands. At present, engineers and other skilled staff are becoming available at about the rate of 4,000 per year.

Raw Materials

Between 50,000 and 100,000 tonnes of uranium are estimated to exist in the mineral resources of metropolitan France. About 10,000 tonnes have been shown to exist by galleries and boreholes, the remainder lies in deposits not yet investigated. In Madagascar some 1,000 tonnes of uranium thorianite are known to exist. The mineral consists of between 10 and 20 per cent. uranium and between 60 and 70 per cent. thorium. Prospectors in other overseas territories have so far failed to find further deposits.

It is expected that about 380 tonnes of chemical concentrates containing 60 per cent. uranium will be produced in 1957. Production of materials of nuclear purity, uranium metal and thorium nitrate, over the same period will probably be 300 tonnes in each case. It is hoped that the annual output of uranium will increase to 3,000 tonnes per annum by 1975. Details of the plant, in operation and under construction, for the treatment of ores are given in Table I.

TABLE I *Plant for Treatment of Uranium Ores*

Location	Treatment capacity, tonnes per annum	Uranium content of mineral, per cent.	Uranate output, tonnes per annum
Gueugnon (Saône-et-Loire)	50,000	0·1—0·8	300
Ecarpière (Loire-Atlantique) (under construction) ..	300,000	0·11—0·15	400
Bessines (Haute-Vienne) (under construction) ..	200,000	0·11—0·25	450

At Gueugnon, which came into operation in the spring of 1955, the mineral is treated by a chemical method. The plant at Ecarpière, which is partly constructed, will use a similar method. The concentrated ores are processed at the plant at Le Bouchet. All of the natural uranium in the various French piles comes from this plant. Further equipment for the treatment of thorium ores and the purification of the element is under construction at Le Bouchet. The location of C.É.A. sites is shown in Fig. 2.

Recently, the cost of uranium concentrates produced by C.É.A. was announced as 12,000 francs per kg, but the figure is likely to be reduced to 10,000. Similarly, it is likely that the cost of converting the concentrates to the raw metal will be reduced from 5,000 to 4,000 francs per kg.

France has a sufficient supply of nuclear graphite to meet its needs. That supplied by Société Pechiney has a four millibarns cross-section for thermal neutrons and so is quite suitable for gas-cooled reactors.

A large workshop devoted to the machining of graphite is in operation at Marcoule. The Société des Forges et Ateliers du Creusot was responsible for the design and engineering of the graphite-machining equipment.

The French are giving serious study to the natural-uranium/beryllia system. The beryllia (BeO) that they have produced for reactors is a ceramic of density 3. It is made into bricks with a face of 50 × 100 mm. In their studies they built up a small assembly using uranium bars 29·2 mm. in diameter with aluminium sheaths 1 mm. thick. The bars were carried in square channels having a 150 mm. side. Calculations made from the results obtained showed that, without a reflector, 7·2 tonnes of uranium and 33·4 tonnes of beryllia were needed for divergence. In order to show the comparison with other moderators, figures have been given showing the tonnage of uranium required to produce divergence when a graphite reflector is present. The figures are: heavy water, 1·5; beryllia, 3·5; graphite, 19·0.

Research

About 6,000 employees carry out the C.É.A. research and development programme. Of these about 1,200 are nuclear engineers. The main centres are at Châtillon, Saclay and Grenoble. A feature of the Franch programme is the independent manner in which they have pursued their nuclear studies.

Châtillon

The name of the centre at Châtillon is actually the Centre d'Études Nucléaires de Fontenay aux Roses, but the long title is rarely used. The first French pile was operated at Châtillon in December, 1948. A power of 5 kW was reached and the pile has been referred to as EL1 or Zoé. Natural uranium oxide was used as fuel.

Lately Zoé has been extensively modified and her output increased considerably. The fuel is now natural uranium (1·88 tonnes), and heavy water (4·2 tonnes) serves as moderator and coolant. A power of 150 kW is achieved.

The core is contained in an aluminium shell 180 cm. in diameter. A graphite reflector and concrete biological shield surround the shell. Extensive use has been made of the pile, for the researches necessary to construct the more powerful piles at Saclay and Marcoule.

The Department of Chemistry has its radio isotopes service centred at Châtillon. In 1955, about 4,000 deliveries were made, of which 75 per cent. were materials of French origin. The larger part of the remainder came from England.

A study of treatment methods for low-grade ores is carried out there. Results of these researches are embodied in the plant at Gueugnon and Vendée. Also the first processing of irradiated uranium was carried out at Châtillon. It was a chemical method and plutonium was first obtained in November, 1949. A pilot plutonium separation plant was then constructed with the aid of industry. This plant formed the basis for the installation at Marcoule. The study of the metallurgy of plutonium has been proceeding at Châtillon.

A small enriched-fuel reactor is under construction there. Called Minerve, it is to come into operation in 1959. Operation will be at a power of 1 watt and it will be used for studies in reactivity. In particular it will be used to examine the properties of spent fuel using the oscillation method.

Another reactor under construction, and scheduled for completion at about the same time as Minerve, is Triton. This will be a 1 MW swimming-pool reactor. The uranium fuel elements, which will be enriched to about 20 per cent., are to be fabricated in the United States. Triton will serve as a source for the study of shielding for the protection of materials and personnel. It is expected that the flux will be 10^{13} neutrons per sq. cm. per sec.

A group at Châtillon is conducting out-of-pile experiments on liquid metals. A liquid sodium circuit consuming 600 kW and operating at 500 deg. C. is in service.

Saclay

It is usual to compare Saclay with Harwell. The aerial photograph, Fig. 3, shows that the comparison is to some extent justifiable. Primarily Saclay is a research centre. It prepares the way for the industrial use of nuclear energy.

The health-physics service left Châtillon for Saclay in 1955. Studies are being made of the effect of radiation on organisms and also of the nature of photo-synthesis and the occurrence of mutations in vegetables. Clinical and diagnostic techniques are investigated. The electronic development service and the documentation service are also centred at the establishment.

The department of pile studies is at Saclay. At present one pile, called EL2 or P2, is in operation. Three others, EL3, Aquilon and Proserpine, are expected to be operating very soon.

EL2 is a natural-uranium heavy-water pile that has a flux at its centre of about 10^{13} neutrons per sq. cm. per sec. By circulating the heavy-water—it was originally stagnant—the power has been raised from 1·5 to 2·4 MW. Surrounding the core is a graphite reflector 90 cm. thick. Outside this is an iron shield 20 cm. thick and a concrete shield 220 cm. thick. Carbon dioxide at a pressure of 10 atmospheres is used as the coolant, and has enabled valuable experience to be gained with closed-circuit systems.

By July 16, 1956, 350 kW-days had been produced by the pile. As the pile contains about three tonnes of uranium, each tonne had yielded about 115 MW-days. After this date the pile was replenished because trouble was experienced with burst slugs.

As an example of the work carried out in the pile the programme for the week of April 29 to May 6, 1957, can be given:

The pile EL3, which should diverge soon, is a materials-testing reactor. Uranium slightly enriched (just over 1 per cent.) is used; heavy

Fig. 2 At present work concerned with atomic energy is fairly evenly scattered through France, except in the Northern industrial area.

Fig. 3 This aerial view of Saclay, taken in 1956, shows the resemblance to Harwell. The building starting in the right background is the EL-3 reactor.

Channel	Use
(Horizontal)	
E1	Study of crystal structures by neutron diffraction.
E2	Badly situated—never used.
S4 and S8	Fabrication of radio-isotopes.
S1 and S3	Studies of corrosion in the presence of still water.
Ni	Measurement of the modulus of elasticity of a magnesium alloy under irradiation.
N2	Experiments with fuel elements sheathed in zirconium—temperature 400 deg. C., atmosphere of carbon dioxide.
N3	Irradiation of enriched uranium, to study its behaviour.
N4	Measurement of the resistivity of irradiated niobium and tantalum. Liquid nitrogen circulated.
N5	Irradiation of rats.
N6	Irradiation of graphite in a carbon dioxide system—temperature 450 deg. C., pressure 15 HPZ.
N7	Irradiation of magnesium in an atmosphere of carbon dioxide at a pressure of 15 HPZ.
N8	Study of burst-slug detection in an aqueous medium.
N9	Reserved for a study of corrosion of metal heated in a humid atmosphere.
N10	Irradiation of graphite and structural materials.
(Vertical)	
Centre	About a dozen containers in which a variety of items are being irradiated.
CV1 and CV2	Irradiation of quartz and graphite.

water forms the moderator and coolant. A flux of 10^{14} neutrons per sq. cm. per sec. is expected. An experimental channel will be devoted to liquid-sodium investigations.

Aquilon, a reactor to be used for lattice studies, should also come into operation soon. It will be operated at a power level of 1 watt. Experiments will be carried out on enriched-uranium/ordinary water and natural-uranium/heavy-water systems.

For criticality studies with aqueous plutonium sulphate solutions, the homogeneous reactor Proserpine is being constructed. A beryllia reflector is to be used and the French claim that their spring-operated safety rods are the fastest in the world.

Most of the important accelerators are at Saclay. There are two Van der Graaff generators, of 2 and 5 MV. There is also a cyclotron that produces 25 MeV deutrons. It has been used to accelerate the ionised atoms of oxygen, carbon, and nitrogen. In Fig. 4 is shown the 2,000 MeV proton synchrotron that is under construction at Saclay. France also possesses a 35 MeV electron linear accelerator for the production of fast neutrons.

Grenoble

October, 1955, saw the creation of a new centre for nuclear studies at Grenoble. In this way C.É.A. feel they have demonstrated their desire to collaborate with the University of Grenoble and to avoid an excessive centralisation of research in France. The centre is also situated conveniently near a modern industrial region.

Grenoble will be complementary to Saclay. Amongst other things, studies will be made in solid-state physics and magnetism, heat exchange, and metallurgy. A swimming-pool reactor will be installed. Mélusine, as it will be called, is to be similar to Triton, and will find application in studies of radio-chemistry, hydrogen behaviour in pile, and neutron diffraction. As M. Yvon, director of the pile study department, put it "*Mélusine disposera de grands moyens intellectuels.*"

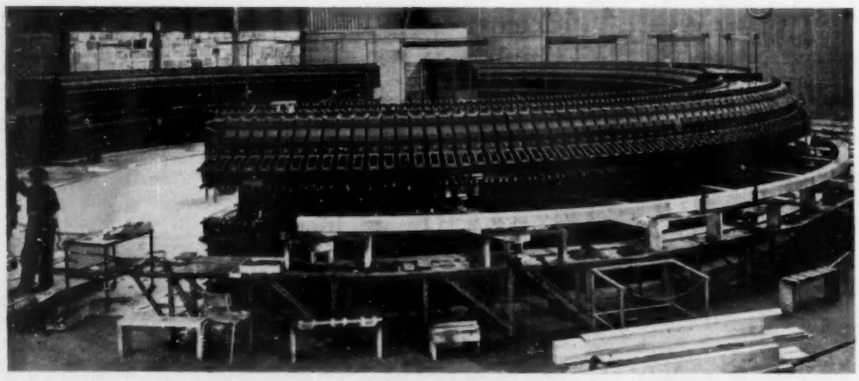


Fig. 4 A 2,000 MeV proton synchrotron is under construction at Saclay.

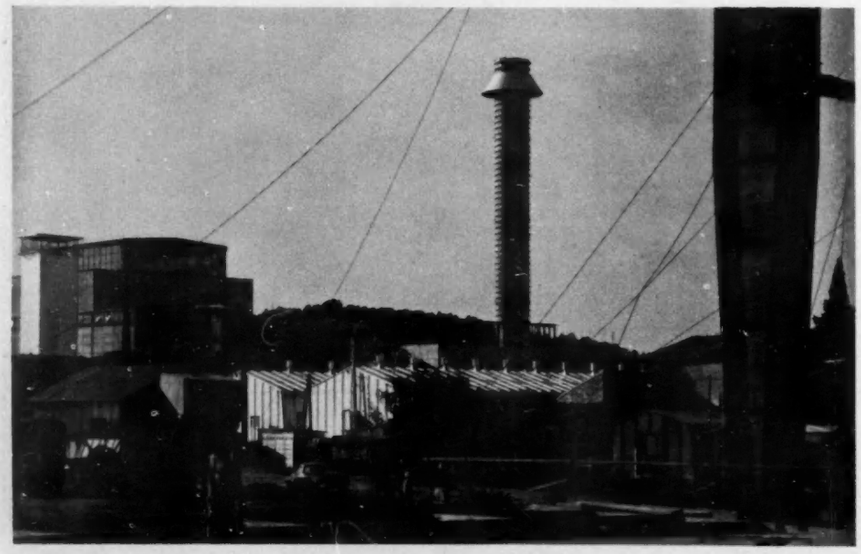


Fig. 5 The 100 metre chimney for the exhaust air of reactor G1 at Marcoule is very reminiscent of that at Windscale.

Power

Having chosen "*la voie du plutonium*," the French set about creating a plutonium production centre. The site of the centre, Marcoule, now contains one operating reactor, G1, a spent-fuel processing plant that is almost complete, and two large reactors, G2 and G3, under construction. The plant can be compared with the Calder-Windscale combination.

Marcoule

Reactor G1 was designed for a thermal power of 40 MW but as yet it is operating regularly at 32 MW. It is a natural-uranium graphite-moderated pile that is air cooled. The air is drawn in through a low chimney, filtered, blown through the reactor and exhausted through a chimney 100 metres high, shown in Fig. 5. About 20 tons of natural uranium make up the pile.

To gain experience under the conditions met with in nuclear reactors, Electricité de France have constructed a 5 MW generating plant that extracts some of the heat from the air leaving the pile. A vertical turbine is used in conjunction with a heat exchanger. The air leaves the pile at about 130 deg. C. and from this steam at 105 deg. C. is obtained. It is hoped that air temperatures of 180 deg. C. will eventually be achieved. The low temperature of the steam requires an elaborate system for removing condensed steam from the turbine.

The fuel rods are about 2 metres long and are sheathed in magnesium. The sheath has six fins to facilitate cooling. A horizontal arrangement of fuel elements has been adopted: the elements are inserted at one face and withdrawn from the other. The magnesium sheath restricts the temperature at which the element can be operated. To gain the maximum output from each part of the pile the exit of air from each cell in the pile is controlled. There are 2,674 cells with a corresponding number of thermo-couples and regulators. The elements are changed each year and plutonium 239 is the chief isotope obtained.

A quick burst of a fuel element occurred in the pile. The magnesium burnt three-quarters of its length and pellets of uranium oxide were found in the channel. Special tools were needed to extract the broken element but the graphite channel was undamaged.

A view of the fuel processing plant is shown in Fig. 1. The building is 150 metres long, 37 metres wide, and 31 metres high. The processing capacity is secret. At present the long elements from G1 are taken from the pile, cut up, put in special containers and left to "cool" in an underground chamber for 4 months. The containers are then taken by lorry to the processing plant. When the plant is completed it will process the fuel elements from all of the main French reactors. The air within the plant is kept at a pressure slightly below that of the atmosphere.

Chinon

The reactors G2 and G3, at Marcoule, are also mainly for plutonium production but in addition each will generate about 40 MW of electrical power. The first reactor designed specifically for the generation of electricity will be designed and built by Electricité de France at Chinon on the banks of the Loire. The C.É.A. will provide the fuel and the moderator. The reactor, EDF-1, will have an electrical output of 60 MW. Unlike G2, the reactor will have a vertical arrangement of fuel rods. Carbon dioxide will be used at a pressure of 360 lb. per sq. in. Later a second reactor, EDF-2, will be erected on the same site.

Marine Propulsion

Work is in progress on a natural-uranium heavy-water pile for marine propulsion. The first nuclear-powered craft is to be a 5,000 ton submarine, the Q-244. It is to be completed in four years-time. A centre for training crews for nuclear submarines is to be set up at Cherbourg.

In Parliament

DEATH OF A RAILWAY

At a few minutes after midnight recently, Mr. S. O. Davies (Labour) was enabled, by his success in the parliamentary ballot, to commence a short adjournment debate on the fate of the Merthyr Tydfil-Abergavenny Railway, which, he said, the British Transport Commission had threatened to close down completely.

The geographical position of this 24 miles long railway was such that it passed through three counties and some extremely beautiful places, like Govilon, Gilwern, Pontsarn and Abergavenny. It served, potentially, some 200,000 members of the public, but the reason given by the Commission was that the losses which the railway had incurred amounted to about £59,000, and the Commission had tried to salve its conscience by saying that adequate alternative road facilities were available.

Mr. Davies contended that the means adopted by the Commission to prove that the railway had been running at a substantial loss were extraordinary. A figure of £58,939 was stated by that body in April of this year, but when the principal railway trade unions met to discuss the final closing down, the figure mentioned was £30,000. The possibility of the line being closed had existed for the past two years and it was pertinent to ask why, if the railway was to be shut down owing to its losses, a very substantial sum had recently been spent in the relaying of about eight miles of the permanent way. That distance represented about one-third of the railway's length and it had been stated by competent railway men that it could cost up to £20,000 or £25,000 a mile to re-lay the permanent way. Stations had been re-painted within the last two years, one, Mr. Davies emphasised, in his own constituency of Merthyr Tydfil. The tunnel near Brynmawr had been repaired. Why? There were suspicions by some people that the expenditure was incurred so that the Commission could point to the losses on the line and so justify the closing.

FREIGHT-HANDLING COMPLICATIONS

The Commission had told him that it derived the greater part of its income from the transport of goods; yet, a very short time ago, the railway was closed to freight traffic. Many examples could be given of what had resulted. An important works in his constituency was connected with another great works on the North-East Coast and a spur line ran into the local works. Traffic between the two, instead of going direct to Abergavenny, was now taken there via a steep gradient through the Brecknock Beacons and a remote junction called Talyllyn. Coal from nearby Blaenavon for the steelworks at Ebbw Vale had to go 30 miles over extremely difficult junctions through the heart of Monmouthshire, instead of eight miles, through the Beaufort Junction. The Commission had had to decline the handling of opencast coal mined in the area.

TRANSPORT COMMISSION'S OBLIGATIONS

In his reply, Mr. G. R. H. Nugent, Joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation, said that the matter was now before the Transport Users' Consultative Committee for Wales and Monmouth, which was acting as the investigator appointed by Parliament under the 1947 Act, and, therefore, it would not be proper for him to discuss in any detail the facts and merits of the issues advanced.

It was the policy of the Commission to maintain branch lines in the rural areas as far as possible, but it had to be borne in mind that these lines were laid down 100 years ago, before the advent of the motor car and in very different circumstances from those now existing. In endeavouring to keep these branch lines open, the Commission had to consider how to reduce operational costs and increase traffic. Mr. Davies had suggested that it might be possible to use Diesel cars and no doubt the Commission had considered that aspect. It had developed different types of light Diesel cars and one type being used experimentally on the Banbury-to-Bletchley line was cheaper than some others to run because only one driver was required instead of two and there was less maintenance work. Even so, there was a limit to what could be achieved in this direction.

The business of the Commission was to carry all the traffic it could and it did not intend to closed own lines unless it had to, but, taking one year with another, the Commission must pay its way, in accordance with the duty imposed on it by Parliament. The Commission had been assisted by Parliament to engage in a great modernisation scheme, in order to provide the country with a first-class modern railway system. In that context, the Commission would certainly keep in use every branch line it could.

REPLACING STEEL IN BUILDINGS

Attention was drawn by Surgeon Lieut.-Commander R. F. B. Bennett (Conservative) to the desirability of eliminating the unnecessary waste of steel in the construction of buildings in this country by the substitution of reinforced concrete wherever possible. On this matter, Mr. Hugh Molson, the Minister of Works, said that he had no means of estimating the extent to which reinforced concrete may have been preferred to steel for the construction of buildings during the past year, but, at the same time, he had no reason to believe that designers generally were not aware of the advantages of reinforced concrete in many circumstances. He believed that the greatest encouragement which he could give was by example. Out of 251 buildings designed at the headquarters of the Ministry of Works during the past twelve months, 163 had been for construction in reinforced concrete and 15 for construction in steel and reinforced concrete, combined.

INCREASING TRADE WITH CANADA

Questions were put to the President of the Board of Trade by Mr. Ronald Russell (Conservative), asking what restrictions were still imposed on the import of manufactured goods into this country from Canada and to what extent British industry was able to take advantage of Canada's need to import larger quantities of capital equipment. Mr. Derek Walker-Smith, Minister of State to the Board of Trade, replied that, in general, for balance of payments reasons, manufactured goods from Canada could only be imported under licence to meet specific British requirements. Consumer goods were licensed only under the token import scheme. Some manufactured goods, however, would be covered by the decision that a number of commodities used in industry would be freed from control as from August 1 last.

British exports of capital equipment to Canada, Mr. Walker-Smith added, were substantial and had been increasing. This country's industry had, in fact, the manufacturing capacity to supply more of Canada's needs and he was confident that, given determined sales efforts, exports could be further increased.

Technical Careers for Girls

The need for the Ministry of Education to do all in its power to encourage a greater proportion of girls to take up scientific and engineering careers was emphasised in a question put to the Parliamentary Secretary to the Ministry by Mr. Richard Fort (Conservative). Sir Edward Boyle, Bt., informed the House, in his reply, that the main responsibility of the Ministry was to see that girls had the chance of a sound scientific education. He believed that school authorities generally were very ready to give the Youth Employment Service and representatives of industry facilities for interesting girls in such careers, but he was glad to take the opportunity now afforded him of stating how important it was that they should take such steps.

New Scottish Technical Colleges

The Secretary of State for Scotland was asked by Mr. W. Ross (Labour) respecting the progress being made in the provision of the proposed technical colleges at Kilmarnock and Ayr. In reply, Mr. John Maclay said that the accommodation for the first development of the new college at Ayr was settled and that the education authority concerned aimed at starting building by next year. They were also considering the accommodation which would be required for a college at Kilmarnock, with a view to commencing the building operations by 1960.

Scottish Graduates for Scottish Firms

Mr. Malcolm MacPherson asked what steps the Secretary of State for Scotland was taking to encourage Scottish industry to take more Scottish graduates into its service. He was told by Mr. John Maclay that, in co-operation with the Scottish Council (Development and Industry), the Scottish Board for Industry, and other bodies, the Government had taken every opportunity for urging upon industry the advantages of increasing their employment of persons trained at universities and technical colleges.

No Work for Peterlee

Difficulties involved in the finding of work for the recently-created townships were raised by Mr. Emanuel Shinwell (Labour). He asked the President of the Board of Trade whether he was aware that the new town of Peterlee possessed only two light industries, although its population was expected to reach 20,000 during the next few years. Mr. F. J. Erroll, the Parliamentary Secretary to the Board of Trade, said that the Department was trying to interest suitable firms in the town, but had so far found none who were willing to go there.

Clean Air Council

Replying to Mr. Philips Price (Labour), who asked for an up-to-date account of the work of the recently-established Clean Air Council, Mr. Henry Brooke, the Minister of Housing and Local Government, said that the Council had held one meeting, which took place on July 11. The principal subjects of discussion had been the actions taken since the passing of the Clean Air Act, 1956, and the research and development work on air-pollution problems. The next time the Council proposed to meet was in the autumn.

Supplies of Smokeless Fuel

Answering a question by Mr. G. Nabarro (Conservative) as to the prospects of the solid-smokeless-fuel industry, Mr. Reginald Maudling, the Paymaster-General, stated that the total production of such fuels in 1956 was about 34 million tons, excluding supplies of hard coke to blast furnaces and foundries. Production during 1957 would probably be at about the same level. In subsequent years, production would largely depend upon demand and there was no reason to suppose that shortages of supplies would delay progress in putting into effect the provisions of the Clean Air Act, 1956.

Wolfram Deposits in Uganda

The Secretary of State for the Colonies was asked by Mr. J. Dugdale (Labour) what steps were being taken to renew the contracts for the bulk purchase of wolfram in Uganda, in view of the threat to the industry arising from the fall in the world price and the burden of the industry's mechanisation programme. Mr. Walker-Smith, replying for Mr. Alan Lennox-Boyd, said that the Government regretted that they did not see their way to renewing these contracts, which expired in September. The situation had changed radically since the contracts were placed at the end of 1952. Tungsten ores were now in ample supply and, in consequence, their price had fallen greatly.

THE HUMAN ELEMENT

Sympathy is Not Enough

Engineers sometimes get the reputation of being somewhat objective in their approach to human relations. It is doubtful if this distinction is any more earned by engineers than by the physicist or chemist, except that it has sometimes been engineers who have offered unorthodox remedies for our economic ills based on a disregard of human motivation. In general, however, the engineer of mature judgment is as sympathetic towards other human beings and of the need to handle them with tact as anyone else who has absorbed a difficult intellectual discipline in formative years.

From time to time, large engineering concerns set up courses to deal with this problem. One such is described in the latest issue of the *Westinghouse Engineer*. Discussions based on something like a syndicate system were found to be useful in bringing a greater understanding of the human side of the engineer's work to men who thought that they were already fully aware of the issues involved. The problem, therefore, is to remove the idea that the senior engineer already knows everything about human relations rather than to persuade him that such things exist and must be taken into account. There must be many engineers to-day who have missed the higher administrative jobs in their companies, not because they ignored human relations, but because they mistakenly thought they knew all about them.

Pension Dispensation

Some of Britain's growing body of older workers are to be given an opportunity to step up their pensions when eventually they retire, under the National Insurance Act, 1957, which comes into operation on August 5. Men under 70 and women under 65 who are still working can, by giving up their pensions and by paying full national insurance contributions, add 1*s*. 6*d*. a week to their eventual pension for every 25 contributions paid for weeks of employment. A man who works an extra five years and takes advantage of the scheme will find his pension increased by 15*s*. a week at the end of the period. Provided something is done to keep up the pension's purchasing power (and that of the increases) this might prove a worthwhile reward for working longer though the provident worker would not be much worse off if he saved and invested his pension while continuing to work.

Another measure under the same Act affects payment of unemployment benefit. No man can now claim benefit for a day on which he does not normally work unless he is unemployed (or sick) on all his normal days in that week. This means that workers on a normal five day week can't have it reduced to four and claim unemployment benefit for Saturday. Few would complain with any justification that this is an unfair amendment, certainly not the taxpayer.

Educating To-morrow's Customer

Slowly—far too slowly—the Overseas Scholarship Scheme sponsored and run by the Federation of British Industries is winning acceptance among engineering companies. When the F.B.I. published their third annual report on the scheme (dated June for the year ending March), the grand old man of engineering education, Sir Arthur P. M. Fleming, found it necessary to say in a foreword to the report, having commented on the rapid expansion of the scheme, that "There are, however, still many engineering firms which could readily take scholars for training, even if only for short periods in specialised fields. I hope that, in the interest of future exports, these firms will respond favourably when approached for such training facilities by our director of studies." By the end of March, 147 F.B.I. overseas scholars had entered Britain from 20 different countries.

The scheme is first rate. Its aims, given in the report are "to assist developing countries by increasing their supply of trained engineers and to stimulate the export of British engineering equipment by the spread of British technical knowledge overseas." This is precisely what is needed to counter the increasing influence of the United States and Russia. In a Weekly Survey note in this issue India's preference for a Russian scheme of heavy engineering development to one submitted by British experts is discussed and deplored. Our ability to train overseas engineers as well if not better than most other nations is the main counter we have to the others' offers of capital.

Scholarship Resources

Information on the considerable help available for those who want to become electrical engineers was first published in booklet form by the British Electrical and Allied Manufacturers Association in December, 1954. Encouraged by the demand for the information, and prodded by the urgency of the industry's need for engineers, BEAMA have published a second edition, *Scholarships and Other Awards available to British Students for Training in Electrical and Allied Engineering*. It takes into account the new need which has arisen "by reason of the key role the industry occupies in the development of nuclear energy for electricity supply" and the great increase in the facilities for technical education during the past two years.

The booklet does not aim to be comprehensive, but seeks to include open scholarships designed specifically for study in electrical engineering. Even so it contains a surprising number of awards and schemes of assistance, first for non-graduates who seek a first degree in electrical engineering, such as the Arthur Fleming Scholarship, the Charles A. Parsons Memorial Scholarship, and over 50 others. Then there are the details of post-graduate scholarships and research awards open to senior students "for advanced work in electrical engineering and allied subjects" and finally scholarships and awards "permitting study abroad for both graduate and non-graduate students." Apart from the foreword and introduction, which discuss briefly the opportunities existing for the electrical engineer, the whole contents are in the nature of a catalogue. It is a most useful book of reference.

Poise in Demand

In a White Paper issued last week, the Government announced a change in the method of recruitment for the Foreign Office. It is to use the written examination to a greater extent as a means of choosing personnel; although the interview is still to be retained as a key part of the examination. The new system is to be tried for a trial period of some five years. As a method of recruitment it has something to recommend it on the assumption, which is reasonable, that a Foreign Office candidate who is good at paper work has not had the same chance to shine as in the examination used by the administrative grade of the Civil Service.

It is difficult to see how it is going to affect the size of the field from which the Foreign Office draws its recruits. There is still a good deal of publicity given to the fact that this department of government draws its personnel from the most presentable social as well as intellectual strata. A moment's reflection will force the conclusion that this is bound to be so. Social poise is part of the diplomat's stock-in-trade and it is rarely acquired by those who have had to fight their way up the intellectual ladder. The young man who is bettering himself is usually better placed in the administrative grade.

Behind all the carping about social snobbery in Foreign Office recruitment lies the fact that this department is placed in the same predicament as the others. It does not find it easy to find new men of the right calibre against the competition of industry—which pays well for its industrial diplomats and its salesmen.

Louder Still and Louder

The irritation caused by jet aircraft flying noisily at low altitudes is a symptom of a wider problem. A letter in *The Times* last week drew attention to the growing problem of the effects in factories in particular of exposure to noise—especially to noises of high frequency. The letter pointed out that the growing mobilisation of energy for industry through power units meant an increasing noise problem. This would take two forms. There was the growing need for protection of the worker exposed to such conditions and for the protection of the company or organisation against unjustified demands for compensation. Thorough analysis of the causes of distress and disability through noise was called for.

This subject was recently considered in a paper prepared by Dr. A. J. King at the request of the Mechanical Engineering Research Laboratory, East Kilbride, and published in ENGINEERING on page 716 in the issue of June 7, 1957, and in the ensuing correspondence. The article discussed methods for measurement of vibration and noise, dealing both with physical and subjective aspects. Methods of reduction of vibration and noise were also considered. The importance of resilient mountings and enclosure was stressed and the need for further research on rolling and sliding contact of metals outlined. To-day there is a greater mobilisation of resources on the problem of noise than ever before, thanks mainly to the development of the jet aircraft engine. It is to be hoped that the engineering and environmental aspects of the problem are handled jointly.

The Compleat Executive

The joke, if such it be, that the good executive in modern business life should be suffering from stomach ulcers dies hard. Such an idea is also a stern criticism of our way of life. The poet who said that we should find time to stand and stare was on to something more significant than he possibly knew. To-day it is fashionable to be harassed and over-worked and we pay the consequences for this kind of indulgence. It is probably no more praiseworthy, and had something in common with the Eighteenth Century over-indulgence of claret and pre-occupation with melancholia.

There is a limit to which this kind of thing should go. The business community in the United States, where such fashions are practised with typical organised ruthlessness, is now thoroughly alert to executives' physical and psychological complaints—one suspects not always on the advice of the best medical opinion. Business magazines display photographs of stomach ulcers and pep-tablet courses in various degrees of subtlety and suggestiveness are freely available. Care will have to be taken that in all this sedulous regard for the modern executive he is not frightened out of his wits by the baleful tales of what is probably going on inside him.

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